

ANATOMY AND PHYSIOLOGY OF YOGIC PRACTICES

M. M. GORE





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ANATOMY AND PHYSIOLOGY OF LOGIC PRACTICE

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Anatomy & physiology
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गुरुकुल कांगड़ी विश्वविद्यालय
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of
C. Y. (Certificate); D. Y. (Diploma in Yoga Education)
courses of all the Yoga Colleges and Universities and
Teacher's Training Courses in Yoga.



ANATOMY AND PHYSIOLOGY OF YOGIC PRACTICES

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KANCHAN PRAKASHAN

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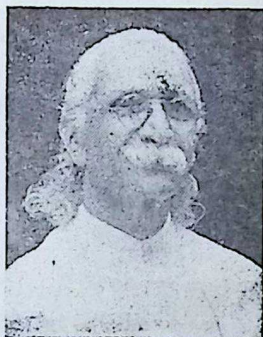
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Dedicated to and in the memory of

Late Swami Kuvalayananda



**A great pioneer of Scientific research in the field of Yoga
& Founder of Kaivalyadhama,
On the occasion of his birth centenary year 1983-84**

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CONTENTS

Foreword

Introduction

1

PART ONE

BASIC ANATOMY AND PHYSIOLOGY

Anatomy and Physiology (introduction)	3
The Cell	5
The Tissues	6
Digestive System	9
Circulatory System	11
Respiratory System	14
Muscular System	20
Nervous System	34
Consciousness and awareness	46
Endocrine System	49
Skeletal System	53
Excretory System	57
Homeostasis	59
Posture	61

PART TWO

ANATOMY AND PHYSIOLOGY OF YOGIC PRACTICES

ASANA	67
Characteristics of Asanas	70
Aims and objectives of Asanas	73
Mechanism of Asanas	74
Classification of Asanas	82
Salient features of Cultural Asanas	83
Relaxative Asanas	89
Meditative Asanas	93
ASANAS AND EXERCISES	96
PRANAYAMA	101
Characteristics of Pranayama	103
Aims and Objectives of Pranayama	107
Different time ratios	109
Mechanism of Pranayama	110
Puraka Phase	111
Kumbhaka Phase	113
Rechaka Phase	116
Double proportion of Rechaka	117
Deep breathing and Pranayama	120

ANULOMA VILOMA	123
UJJAYI PRANAYAMA	129
KAPALBHATI	136
UDDIYANA BANDHA	141
NAULI	147
INDEX	151

121	AMOLYA VILOMA
122	AMAYI PRAYAMA
123	KARLIMATI
124	AMOLYA BANCHA
125	AMULI
126	INDEX

FOREWORD

Knowledge of anatomy and physiology forms the basis for the study of biological sciences. Even for a common man, to understand the health problems and their solution, preliminary knowledge of this subject is helpful.

Today yogic practices have become popular throughout the world. But there are great many misconceptions about these practices due to the lack of scientific information about them. Yogic practices are generally looked upon as exercises and many a time interpreted in the light of exercise physiology. The physiology of yogic practices differs greatly from that of exercise physiology. This needs basic understanding of the concept of yoga and its relation with the techniques. The nature of every yogic practice is psycho-physiological and if this conceptual background is not clearly understood, the whole outlook on yogic practices will be distorted. The rationale of yogic practices in terms of anatomy and physiology would remove many misconceptions about them.

Anatomy and physiology of yogic practices is a subject which is not yet quite developed. In the educational institutions where yoga courses are introduced, the students are taught anatomy and physiology of

yogic practices as a subject. However, no text book, devoted to this subject was available.

Shri Makarand Gore has been teaching this subject to the students of G. S. college of yoga and cultural synthesis for quite some years. Out of a long felt need of the students of yoga, this book is written. It gives an adequate idea about the subject and will be found useful for the students of yoga as well as for the common man, interested to know the scientific basis of various yoga practices.

I am very happy to welcome a new and timely addition of this book on the technical subject. I give my compliments to Shri M. M. Gore for bringing out this book for the benefit of the students of yoga and recommend it to the readers.

25th Dec. 1984 — **Dr. M. L. Gharote**

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Cultural synthesis.

Asstt. Director of Research,
Scientific Research Deptt.,
Kaivalyadhama, Lonavla.

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I sincerely thank all those who have helped me in publishing this book. It is my bounden duty to express my gratitude to Dr. M. L. Gharote who has advised and encouraged me from time to time while preparing this book. I am deeply indebted to my institution—Kaivalyadhama which has been the main source of my knowledge and understanding of yoga up to this stage. Thanks are due to Mr. Sudhakar Khasgiwale for cover design, Mr. Ratnakar Muley for making the blocks, Mr. C. B. Talpade of Amol Art Printers for good and neat printing, my brother Dr. Anand and my student Miss Varsha Joshi for their help in preparing the index. The eternal blessings of my parents, Dr. M. T. Gore and Dr. Mrs. V. M. Gore, have rendered the task easy. Last but not the least, I express my sincere thanks to my wife Mrs. Bharati Gore of Kanchan Prakashan for publishing the book in time.

—M. M. Gore

INTRODUCTION

Yoga literally means Union. The whole system of yoga was developed to attain the highest state of '**Chitta**' or consciousness where everything is merged into absolute consciousness. Patanjali - the father of yoga - has explained eightfold system of Yoga to advance oneself on the spiritual path while Hata-yoga explored the bodily postures - **Asanas** as well as **Pranayamas**, to prepare oneself for the higher yogic practices like Dharna, Dhyana, Samadhi. Today what is in vogue are these Hath-yogic practices i. e. Asanas, pranayamas Bandhas, Mudras, Kriyas etc. which are known to contribute for the physical as well as the mental well being. People have understood the potentiality of these yogic practices as the 'ways and means' to promote and maintain the healthy state of body and mind.

Early scientific investigations carried out by Late Swami Kuvalayanand - the first scientific exponent of yoga (1924-66) - and later by the other scientists during the last few decades could break the mystical sheath over so many yogic practices and reveal their scientific nature. This helped to remove several misconceptions about the yoga practices. Logical and scientific explanations could be given for traditional techniques of various yogic practices in the light of modern sciences like Anatomy, Physiology, Biochemistry etc. due to these researches. Possible psycho-physiological channels through which the yoga practices work inside the body are being understood through these sciences.

Yogic practices have been included in school curriculum where yoga-teacher imparts the yoga training. This yoga training includes mainly the abovementioned practices which involve our bodily structure and function. Just as an engineer must understand the function of the machinery he uses in order to employ it efficiently and to keep it in good condition so every one of us particularly the yoga teachers, instructors and therapists should have a basic knowledge of the structure and function of the human body. This would help us to understand easily the anatomico-physiological mechanisms involved in the yogic practices. It would be clear from the second part of the book that the nature of asanas-pranayamas is different than the physical exercises and so also the responses of the body which a yoga teacher should know in details while teaching.

First part of the book deals with the basic anatomy and physiology. This would prepare the background for even a student of Arts or Commerce, to understand the concept of different yogic practices scientifically.

Second part of the book gives physiology of yogic practices including their technique, effects and the available information about the scientific researches on them. This would definitely help teachers and the students to develop a scientific outlook towards yogic practices.

PART ONE

BASIC ANATOMY & PHYSIOLOGY

Anatomy and physiology are biological sciences.

Anatomy is the science of structure of a living organism. It studies the form and structure of the body and its various organs like bones, muscles, nerves etc. It gives us the knowledge of the construction of the body. How is our body built up? What is it made up of? How are the organs arranged? So many such questions could be answered through the anatomy.

Physiology is the science of the functioning of the body. It tells us about the working of different organs, systems and the processes going on inside the body. How do the organs work? For example the muscles, heart, brain etc. What for do they work? How do they cooperate with each other? How are they controlled? Such questions could be answered with the help of this science.

Both these sciences are deeply connected with each other. The structure and function of the organism are inseparable and therefore we are going to study them together for every organ or system.

Obviously the **Human body** consists of three parts mainly **head, trunk and extremities**. Hands are upper extremities and the legs are lower extremities. Trunk is again differentiated into the chest or thoracic part and the abdominal part (Fig. 1). Internally these two parts are separated by the diaphragm.

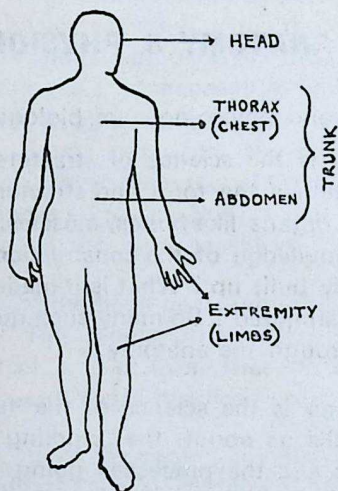


FIG.1 HUMAN BODY

Human body is composed of many systems for example, digestive system, circulatory system respiratory system, nervous system etc. These systems are inter-dependent on each other. The total function of the body depends on the integration among the functions of all the systems.

Any system is composed of some organs having similar functions. These organs work together for the particular system of the body, for example, mouth, teeth, stomach, liver, intestine, pancreas, colon etc. all these organs work for the digestive system with the goal of nutrition.

Every organ is constructed out of some specific tissues, for example a muscle contains muscular tissue. Each tissue is a group of living cells with intercellular substance to do certain function, for example, muscular tissues and nervous tissues are formed by the muscle fibres and nerve fibres which are nothing but the modified cells, for the function of contraction and conduction respectively.

The Cell

Each and every part of the body is composed of tiny or microscopic units i. e. cell. Thus the structural and functional unit of the body is 'cell'. Cells have different shapes and sizes according to their nature of work, for example, muscle cells are spindle shaped, glandular cells are cubical in the form. Every cell is made up of membrane i. e. the cell wall, and the cytoplasm—a living stuff (a colloid substance) which is the physical basis of life. It is because of this cytoplasm that the cell can take the nourishment, it can grow or produce the cells of its own kind, it can respond to the different situations just like an organism. Each cell has a highly specialised central part called the nucleus which controls all the cellular activities (Fig. 2).

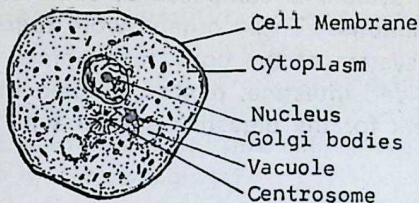


FIG 2. ANIMAL CELL

The Tissues

Several cells combine to form tissues. In some of the tissues the original cells are changed into fibres. Thus the fibres of the nerves and skeletal muscles are only modifications of the cells. Every tissue has got its specialised function to perform. There are mainly four types of tissues.

1. **Epithelial Tissue** forms the external layer of the skin, internal layer or covering of almost all body parts i. e. inner surface of the mucous and serous membranes and makes up the glands. Thus our elementary canal is lined with these epithelial cells. Main functions of this tissue are secretion, protection and absorption. Glandular epithelium of various glands discharge special secretions e. g. hormones from endocrines, digestive juices in the stomach. Ciliated epithelium of respiratory tract protects the tract by expelling dust particles of the inhaled air. Intestinal epithelium absorbs the digested food material from the intestine (Fig. 3 B).

2. **Connective Tissue** forms the blood and lymph as well as dense fibrous connective tissue (Fig. 3 A), cartilages and bones thus helping mainly in the structural frame work of the body. Rigid cartilages of the joints, ear, nose, epiglottis, are few examples. They perform mechanical function. Subcutaneous layer of skin contains adipose tissue which deposits the fat for the body. Bones provide a structural support.

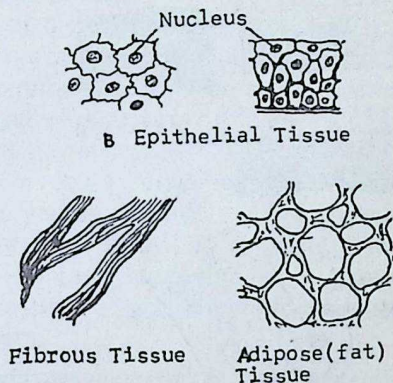


FIG. 3A CONNECTIVE TISSUES

3. **Muscular Tissue** provides various types of muscles to the body. Characteristic of these connecting tissues is their contractility. They form the muscular fibres for smooth and the striated muscles as well. (Fig. 4)
4. **Nervous Tissue** forms the whole nervous system which controls all the processes of the body. It establishes the relationship between the body and

its surrounding environment. The main properties of this tissue are excitability and conductivity. Nervous system responds to various stimuli due to which they are excited. This excitation is transmitted through the nerve fibres in the form of nerve impulse. Nervous tissue is made up of nerve cells and their processes—the nerve fibres (Fig. 4).

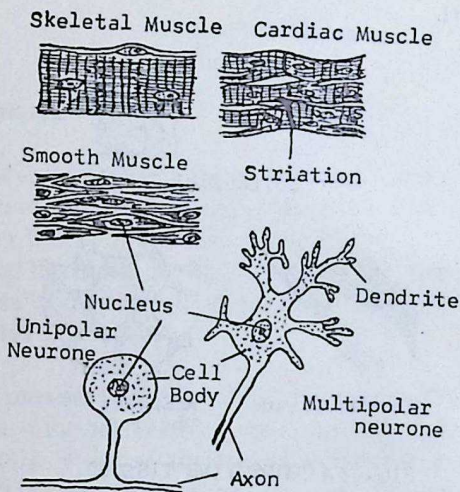


FIG. 4. CONNECTING TISSUES

5. **Reproductive Tissue** : is located in the sex glands. Although this tissue is not very essential to the life of the individual it is essential for the propagation of the species or races.

Organs : There are numerous organs in our body such as bones, muscles, stomach, heart, brain, liver, colon

etc. Each organ has a complex structure which is made up of different types of tissues and perform a specific function for the body; for example the stomach contains smooth muscles, glandular-epithelial tissues, blood vessels, nervous tissues etc. but performs the function of digestion for the body. Thus all organs are supplied with almost all types of tissues except bones and lymphatic vessels.

Systems : Organs with similar functions are united to form systems of organs such as bony system, muscular system, digestive system, respiratory system etc. The digestive, respiratory and urogenital organs are known as visceral organs as most of them are in thoracic, abdominal and pelvic cavities. We study all the systems separately for our own convenience, otherwise all the systems are so co-ordinating and interdependent on each other that there exists no separate system or its function. Some organs belong to more than one system e. g. Liver is a part of the alimentary as well as the excretory system.

We would however study these systems separately in order to understand the body as a whole.

DIGESTIVE SYSTEM

It is also known as Alimentary or Gastrointestinal system. It is responsible for the intake, digestion absorption, assimilation of food, water balance, elimination of the residue and some waste products or poisonous substances. Thus the body receives nourishment through this system. The alimentary canal consists of mouth (buccal cavity), throat (pharynx), oesophagus (gullet), stomach, small intestine, large intestine (colon), rectum and

anus (fig. 5). The canal is a continuous tube associated with salivary glands and other digestive glands. Liver is the largest gland in the body. It is situated in the right side of the abdomen just below the diaphragm. It produces bile—an important juice—for digestion. Digestive glands secrete juices which except bile contain enzymes and other substances to break down the food particles into simpler soluble substances. Proteins, fats and carbohydrates (sugar, starch) are three important nutrients of our food. They are digested due to chemical actions of enzymes. Now this digested food is easily absorbed through the minute blood vessels in the inner wall of the small intestine. Absorbed food is carried to the liver and then into the circulation.

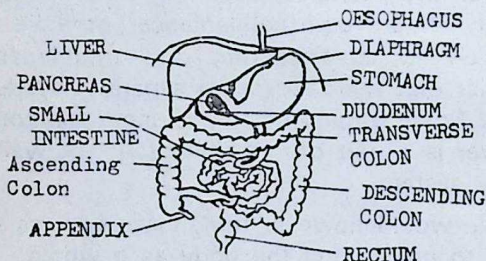


FIG. 5. ALIMENTARY SYSTEM

Colon or the large intestine is about 1.5 meters long and is divided mainly into ascending, transverse and descending colon and rectum (Fig. 5). This part is important from the point of 'Basti' for a yoga student.

Undigested, unwanted residues of food are passed to the rectum and then eliminated through the anus

during the process of defaecation i. e. the evacuation of the bowel.

The muscles of the organs of digestive system are not working under our will hence they are known as involuntary (smooth) muscles. Longitudinal and circular muscles of the walls of the intestine contract resulting in a wave like periodic movements of the small intestine from stomach to the large intestine. These movements are known as peristaltic movements which move the food along the digestive tract.

Another function of the digestive system besides digestion and important for the students of yoga, is its contribution to the visceral awareness. The whole digestive tract is equipped with the nerve fibres and their endings. Sensory nerve endings (receptors) perceive various types of stimuli from the walls of the digestive tract and convey them to the central nervous system, thus causing arousal of the cerebral cortex. We become aware of the sensation from the stomach before usual lunch or dinner time which is interpreted as hunger! Sometimes we also become aware of the sensation of pressure, pain, temperature burning in the viscera.

All these visceral organs are well supported and protected by means of very strong muscles that form the wall of the belly. This wall not only prevents displacement of the stomach and intestine but by its massaging effect also helps to maintain the tone of the involuntary muscles within their walls.

CIRCULATORY SYSTEM

This system carries the products of digestion from the alimentary canal and oxygen from the lungs

to each and every cell with the help of blood. The blood is a vehicle for transport between all the systems. Circulatory system is composed of Heart, blood vessels, and the blood.

Average total quantity of blood in a healthy adult human body is approximately 5 liters which is constantly circulated in the body. Blood has two parts: (1) Blood cells, and (2) Plasma-a liquid part. Blood cells are of three types. Red Blood Cells (R. B. C.) or Erythrocytes, White Blood Cells (W. B. C.) or leucocytes and blood platelets. R. B. C. contains Haemoglobin which can carry O_2 with it. When blood flows through tissues it brings oxygen, nutritional material, salts to them which they pick up for their nutrition. While going away from the cells, the blood is loaded with toxic substances like CO_2 and urea which the cells throw into it as waste products. Leucocytes perform a protective function. They destroy bacteria and foreign organic particles. Blood platelets are irregular in shape. They help in the process of blood clotting. Leucocytes are further distinguished as Eosinophils, Basophils and Neutrophils.

Plasma is a viscous, proteinous fluid. It consists of 90 percent water and 10 percent organic and inorganic substances as well as the antibodies which play a protective role against various bacteria, virus organisms and toxins.

Blood possesses an ability to clot when it comes in contact directly with the air. The blood platelets are destroyed and they liberate thrombokinese. Thrombokinese converts inactive thrombogen into active thrombin. Fibrinogen is converted into fibrin a dense substance in

the presence of thrombin. Filaments of fibrin get intertwined and thus a clot is formed at the injured part of the body within 3 to 4 minutes which prevents further bleeding.

The duty of ceaseless circulation or flowing of blood is attributed to the heart. It is the central pumping station from which the blood is pumped into the arteries with a great force for its circulation in the body (Fig. 7).

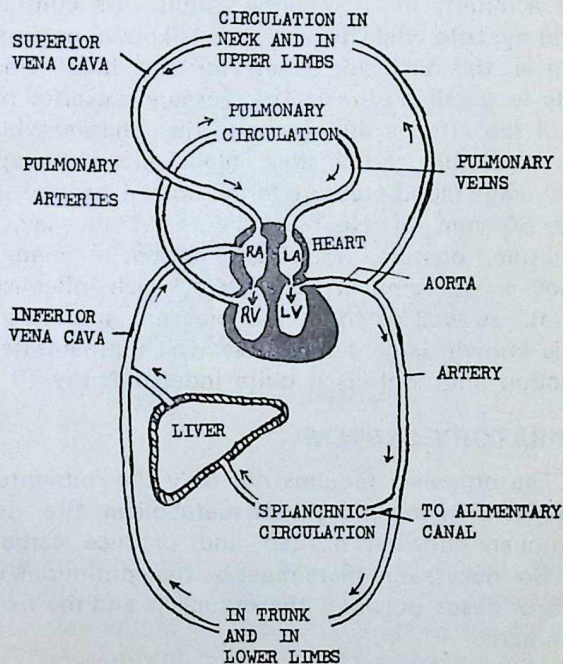


FIG. 6. BLOOD CIRCULATION

After the pure blood is supplied to the organs through the arteries and their capillaries, it is collected back into the veins and brought to the heart. This impure blood is then taken to the lungs where it is purified or oxygenated and conveyed back to the heart for circulation again (See Fig. 6).

Heart is an involuntary muscle which contracts and relaxes automatically for average 70 times (Heart beats) a minute in a healthy adult. Its contraction is called **systole** while its relaxation is known as **diastole**. Systole is the time of action for the heart whereas diastole is the time of rest. The pressure is exerted on the walls of the arteries during both the phases which is known as systolic and diastolic blood pressure respectively. Average blood pressure for a normal healthy adult is 120/80 mm of Hg. Sex, time of the day, body temperature, posture, exercise, emotion, oxygen lack, metabolism are some of the factors which influence the heart rate as well as the blood pressure. muscle of the heart is known as cardiac muscle which initiates its own contraction and controls it quite independently.

RESPIRATORY SYSTEM

The organism requires not only the nutrients but also oxygen. In the process of metabolism the tissues continuously consume oxygen and produce carbon-dioxide. So necessarily there must be the continuous interchange of gases between the organism and the external environment.

Respiration is the process by which oxygen is taken in from the environment, food material is oxidised

and carbon-di-oxide—the gaseous end-product of this oxidation is given off.

Respiratory organs may be divided into two :—

1. The air passages through which the inhaled and exhaled air passes (see Fig 7) and 2. Respiratory part i. e. pulmonary alveoli where gases between air and the blood are exchanged.

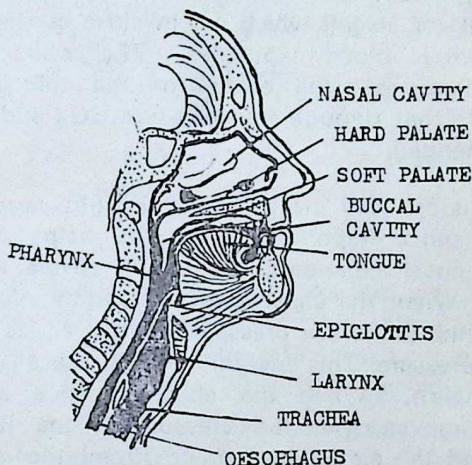


FIG. 7 UPPER RESPIRATORY TRACT

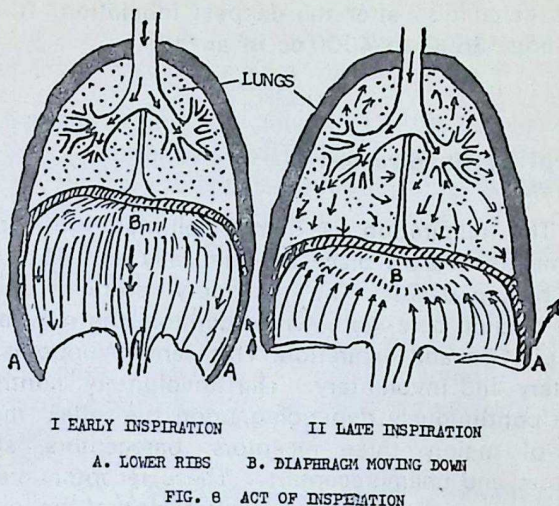
Respiratory passage consists of Nasal Cavity, Naso-pharynx, Larynx, Trachea and Bronchi. Nasal cavity communicates within the trachea. Trachea divides into left and right bronchi. The respiratory tract (passage) is mostly made up of cartilagenous material and never collapse.

The tension or relaxation of the vocal cords and the constriction or dilatation of the glottis depends on the laryngeal muscle which is important for the pitch and note of the sound produced during exhalation.

Bronchi open up into lungs on right and left sides. On the right side there are three lobes and on the left there are two lobes of the lungs. Lungs are made up of a spongy substance. They are composed of numerous tiny air cells or alveoli which are in close contact with the microscopic blood capillaries. The walls of the blood capillaries and the alveoli are so thin and lie side by side that through this partition CO_2 and O_2 are easily exchanged.

Lungs are well protected in air-tight cage made up of ribs and a diaphragm. With the help of these structures, chest expands and contracts several times in a minute. When the chest contracts and the diaphragm moves up the lungs are pressed and the air is forced out under pressure. This 'breathing out' process is known as **exhalation**. When the chest expands and the diaphragm moves down the pressure in the lungs is lowered and the air is sucked up from the atmosphere. This 'breathing in' process is called **inhalation**. (See Fig. 8) Both inhalation and exhalation together constitute the act of respiration.

During the inspiration the fresh air comes in contact with the blood in the lungs. Through the thin walls of the blood capillary and air cell the CO_2 is allowed to escape from and O_2 to come in the blood in exchange. So the blood while circulating through the lungs during



inspiration obtains oxygen from the air cells and lends instead its CO_2 to the air cells. Now the air is expelled out during exhalation. The rate of respiration in a healthy adult is about 14 to 20 respirations per minute.

We inhale about 500 cc air (tidal volume) during inspiration and expel same amount of air in exhalation. 500 cc of air contains about 100 cc of oxygen (20%) But we take only about 25 cc of oxygen from this air and return nearly an equal quantity of CO_2 . Maximum volume of air that we can inhale after an ordinary(normal) exhalation is 2500 cc. This is known as **inspiratory capacity**. The maximum volume which we can exhale at the end of normal exhalation is 1000 cc and is known as **Expiratory reserve volume**. **Vital capacity** of the lungs is the volume of air that can be expelled by the most

forcible exhalation after the deepest inhalation. It averages about 3500 to 4000 cc in an adult.

Control of Respiration

The respiration is semi-involuntary in nature. That means it takes place automatically as well as controlled by our desire. The respiratory centre is situated in the medula oblongata which controls the movements of inspiration and expiration. This central control is both voluntary and involuntary. The involuntary control is acting continuously depending upon the reflex mechanisms of mainly three receptors, baroreceptors, stretch receptors and chemoreceptors. These receptors are sensitive to pressure in the lungs, stretching of the muscles and presence of CO_2 tension in the blood respectively. Involuntary control functions when we are not thinking about our breathing at all. It does not require our attention. Such breathing is a normal or natural breathing. Lack of O_2 can also excite respiratory centre. When we make changes in the depth and duration of inhalation or exhalation etc. it becomes a voluntary control. Thus the respiratory centre is also influenced by the impulses from higher centres in the brain i. e. cerebral cortex. By volition we can breathe in any manner and at any rate we please. We can also hold our breath upto a certain limit.

Emotions can influence our breathing through the cortex. An emotion like excitement can accelerate the respiration e. g. Psychological tension before any athletic event may increase the rate and depth of respiration.

Emotions and thoughts are expressed through the respiration. We release tension when we exhale and we become more active when we inhale.

Speaking, singing, blowing the air are voluntary respiratory (expiratory) acts where as sneezing and coughing are the protective respiratory acts which are performed reflexly by the medula oblongata. In these reflex actions the abdominal muscles are specially brought into action. Coughing is in the response to irritation of the mucous membrane of larynx, pharynx or bronchi by particles of dust, food etc. Cough expels these substances from the air passages, sneezing occurs in response to irritation of the mucous membrane of the inner nose.

As a result of increased muscular work an excess of carbon-di-oxide accumulates in the blood. Demand of O_2 is also increased. Respiratory centre is excited immediately at the end of every exhalation as the same rate and depth of inhalation is not sufficient to eliminate CO_2 and therefore the respiration is accelerated so that the accumulated CO_2 is quickly eliminated from the blood.

Respiratory system also contributes to the awareness. Thermoregulation, water balance, detoxication and excretion are other functions of respiratory system. As a matter of fact, abdominal breathing predominates in males in which the diaphragm moves prominently to increase the thoracic cavity vertically. Costal or thoracic breathing predominates in females where the thoracic cavity increases in size due to other respiratory muscles such as intercostal muscles.

Composition of inspired and expired air

The atmospheric air which enters in the lungs during inhalation is called **inspired air**. The air which passes out during exhalation is called **expired air**. The air which could be expelled even after the normal exhalation, comes from the alveoli and therefore known as alveolar air. The average composition of inhaled air, exhaled air and alveolar air is given below.

	OXYGEN	CARBON -DI OXIDE	NITROGEN AND OTHER GASES
Inspired air.	20.13 %	0.04 %	79.03 %
Expired air.	16.3 %	4.0 %	79.7 %
Alveolar air.	14.2 %	5.2 %	80.6 %

The pressure of these gases is responsible for their exchange in the lungs.

MUSCULAR SYSTEM

Main functions of the muscular system are 1) Locomotion. 2) Movement. 3) Posture formation and maintenance. 4) Assistance in blood circulation and respiration. 5) Protection of the viscera 6) Production of a force or strength and 7) Support.

Functionally all muscles are divided into two groups.

- 1) Voluntary and 2) Involuntary muscles. Involuntary muscles are further divided into a) Smooth muscles and b) Cardiac muscles. Skeletal muscles are voluntary muscles.

Skeletal muscles are made up of small elongated thread like muscle fibres which are striated. At each end of muscle, the fibrous tissue forms a strong band (Tendon) attached to the bone. Any skeletal muscle works under our will and hence they are called as voluntary muscles, e. g. the muscles of head, trunk, hands, legs, tongue, etc. Each muscle is composed of many muscle bundles covered with the connective tissue sheaths. Each such bundle is composed of united muscle fibres. They may be long up to 12cms and lie parallel to each other. Each skeletal muscle has blood vessels and nerves. Thus they get nutrition. Sensory nerve fibres carry the information (impulses or signals) about the state of the muscle to the brain. Motor nerve fibres transmit the order from the brain to the muscle to contract.

5495

Important sense organs i. e. muscle spindles and tendon organs are situated in muscles and tendons respectively (See Fig. 9). Their function is to protect muscle and tendons in extreme contraction and stretching with the help of reflex actions.

Most of the skeletal muscles extend over the joints to move. The most common types of movements are flexion, extension, abduction, adduction and rotation (see

Fig. 14). Flexor muscles bring about the flexion and are situated generally in the front of the joints or the body. Extensor muscles situated at the back or behind the joints cause extension. Many flexor muscles are known as **agonist** muscles which are engaged in contracting and thus moving a part. **Antagonist** muscles are mostly extensors which act in opposition to the agonists thus extending or unfolding the parts. Usually when flexors contract the extensors relax in co-ordination and proportion and vice versa with the help of nervous system. When the muscle contracts, it shortens and becomes thicker in the middle e. g. we can observe this in biceps of the arm. When they contract, the girth is increased and their length is decreased.

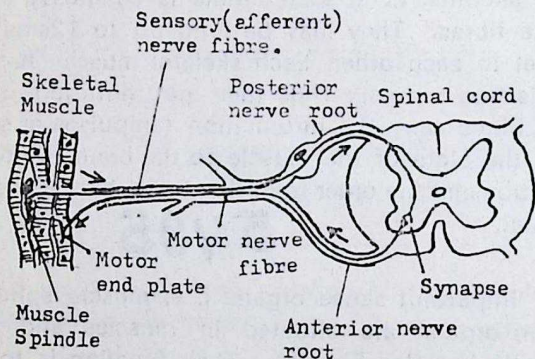


FIG. 9 STRETCH REFLEX ARC

Muscle fibres are of two types **white** and **red** fibres. White fibres contract more rapidly and fatigue more readily. Flexor muscles have a predominance of white fibres. Red fibres predominate more in extensors.

which contract relatively slowly and can maintain contraction for a long time without fatigue.

Voluntary movements are initiated by nerve impulses arising in the motor areas of the cerebral cortex. These impulses travel along the spinal cord to the appropriate muscle causing its contraction. Cortex and cerebellum are very well connected with each other on which the prediction of future movement and position of the body depends. Motor area depends on its connection with sensory area and the sensory nerve impulses coming from the muscles which were previously contracted. During movement the relative position of the limbs and trunk are constantly adjusted to maintain stable equilibrium of the whole body. Thus the voluntary movements are finely controlled due to the neuro-muscular coordination.

Diaphragm

It is probably the most important voluntary muscle in the human body which divides the thorax from the abdomen, serving as a partition between the two. It is a dome shaped muscle and its convex surface touches the heart and the lungs. Its central part consists of a tendon and is called the tendinous centre. The origins of the diaphragm are on sternum, ribs and lumbar vertebrae. The diaphragm has three openings : First for the aorta Second for oesophagus in the lumbar part and the third one for inferior vena cava in the tendinous centre. The vagal nerve also passes down to the abdominal organs through diaphragm. Diaphragm moves up and down several times a minute and participates in respiration.

When it contracts it descends with the result that the vertical diameter of the thorax increases, the lungs expand and an inhalation takes place. This descent of the diaphragm exerts a gentle pressure upon the abdominal organs and gives them a sort of massage which maintains their health. During exhalation diaphragm relaxes to resume its former position. Due to this rising of the diaphragm the thorax decreases thus exerting a pressure on the lungs and hence an exhalation results. Along with the normal inhalation and exhalation the downward and upward movements of diaphragm produce relatively positive (+ve) or negative (-ve) pressures in the visceral cavities which are required for some normal functions like micturation, defecation, inhalation etc. The breathing in which the movement of diaphragm becomes more prominent is known as diaphragmatic breathing. During hiccup there is a sudden contraction of diaphragm causing sharp inhalation.

Abdominal Recti Muscles

These muscles are also known as **Rectus abdominis** muscles. There are vertical skeletal muscle bands in the front wall of the abdomen (Fig. 10). They are situated laterally to the median line i. e. on right and left sides. On the upper side they are attached to the ribs i. e. the cartilages of the fifth-seventh ribs and on the lower side to the pubic bone. These muscles are crossed by 3-4 tendinous bands. Rectus abdominis muscles along with the other muscles support the visceral organs and hold them in their respective places. When abdominal muscles contract they give forward bend to the body. During respiration they move in coordination with the

diaphragm and give massage to different organs in the

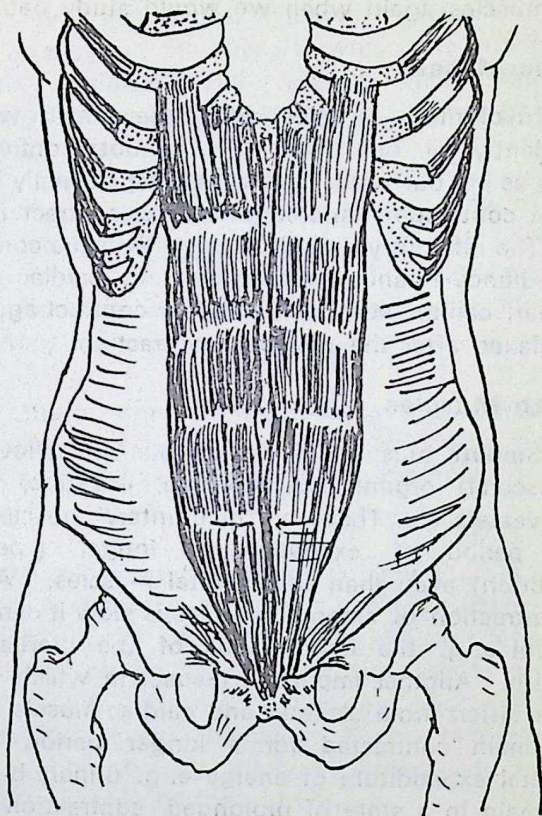


FIG 10 RECTUS ABDOMINIS MUSCLE

abdominal cavity and promote their health. If the proper tension or tone of these muscles is not maintained, they

become loose and abdomen tries to bulge out due to the pressure of the visceral organs. We shall take notice of these muscles again when we would study nauli kriya.

Cardiac Muscle

Involuntary muscles are those which work independently of our will. We cannot control them directly as per our wish. Cardiac muscle normally initiates its own contractions and continues to contract rhythmically. The refractory period is longer than the contraction period, hence tetanus cannot occur in cardiac muscle. The heart cannot stay contracted or contract again until it is relaxed after the previous contraction.

Smooth Muscles

Smooth muscles form the walls of hollow internal (visceral) organs like stomach, intestine, bladder, blood vessels etc. These are involuntary muscles. The latent period of excitation is longer (period of contraction) even than the skeletal muscles. Although the contraction of smooth muscles is slow it can be very powerful e. g. the contractions of the uterus during childbirth. Another important respect in which smooth muscle differs from skeletal and cardiac muscle is that it can remain contracted for a longer period without additional expenditure of energy e. g. urinary bladder. It can remain in a state of prolonged contraction during urination.

Muscle Tone

The basis of posture is **Muscle tone**. The stability and the position of the body depends upon the

muscle tone. Muscles are never completely relaxed even at rest. Any muscle is usually in a state of certain tension or tone even at rest. For example a skeletal muscle is stretched between the bones to which it is attached. This stretching initiates stretch reflexes which maintain an adequate tension in the muscle and thus the position of the body. Since different groups contract in turn, a steady tension is maintained in the whole muscle without any fatigue. In maintaining this tone the metabolism of the muscle is not noticeably increased. Muscle tone is also an example of isometric contraction since the muscle becomes tense without actually shortening.

Muscle tone is fundamentally a simple reflex, regulated by the cortex and influenced by the cerebellum. It is an inherent property of normally innervated muscles at rest.

Muscle tone is a degree of minimum contraction present in resting muscle or it is the resistance offered by muscle to the stretching. This is a sort of preparation of the muscle which forms the basis for any further muscle action. Naturally then an adequate tone is required for the normal activity. Tone is minimum during sleep or it may be completely abolished only by cutting the nerve supply of the muscle.

Muscle tone maintains the position of the limbs at rest, supports the viscera and provides a basal level of muscular contraction on which the active movements can be superimposed. It has also an important muscle pump action on the blood circulation. As each group of

muscle fibres contracts, it squeezes the blood out of its capillaries into the veins and so maintains the flow of blood back to the heart. The strength of a voluntary movement depends also on the tone of that muscle besides the other factors like initial length of the fibres, the number of motor units activated and the size of the muscle fibre.

Different emotional states influence muscle tone. It may be reduced when the individual is sad or depressed and increased when he is happy or confident. Likewise due to these changes in muscle tone, the posture would be affected. For example if the person is depressed, disappointed he is flexed (forward bending) and if he is confident or happy, the extensors contract and he is more extended in structure. Intense excitement or fear may increase tone to an extent where it would interfere with co-ordinated movement and one may become literally be 'scared stiff' due to this strong emotion. Emotions also influence the cardiac and smooth muscles, through autonomic nervous system thus changing their tone.

On the basis of the degree of muscle tone, following conditions may be observed in general.

1. Hypotonic Condition

In this condition the muscle tone is inadequate and remains on the lower level than what is required. Strong emotions like disappointment, depression, failure, sad news, fear, hatred, feeling of insult, unhappiness, affec-

tion, shame, despair, disgust, distress, devotion, gratitude, reduce the muscle tone. The person becomes inactive and sluggish in his action if this reduction in tone is extreme. As the muscles relax more, the flexion of the body occurs. Due to this condition and constant influence of these emotions various abnormal or diseased conditions occur, such as low blood pressure, lack of confidence, drowsiness hypoacidity, colitis, obesity, inferiority complex, headache, flaccidity, atonia, skin troubles etc. He or she becomes passive or slow in action and the tendency to escape from the situation may be developed.

2. Hypertonic Condition

In this condition the muscle tone is increased maximum above the normal optimum level. Muscles offer strong resistance against any movement due to increased tone. Muscles become more rigid and the contractions are so strong that there is no proper movement of the joint or the body part. Strong emotions like extreme happiness, love, anger, jealousy, envy, hope, admiration, greed, increase the muscle tone. Person becomes hyper-active and fast in actions. He may be highly impulsive and of agitating and irritating nature. He may be lean, thin slim or weak but having superiority complex. His ego remains inflated. He is overconfident. Other conditions which may be concomitant to hypertonicity are hypertension, high blood pressure, insomnia spasticity etc.

A yoga teacher must think of these two conditions for his student and teach accordingly, since the perform-

ance and the response of the individuals having either of these two different conditions will be quite different. We would consider these conditions again in the chapter of asanas and how yoga tries to balance these conditions.

Stretch Reflex

Stretch reflex is an important factor in posture and movement. Stretching a muscle little beyond its particular limit causes reflex contraction of the same muscle. We have seen that the skeletal muscle contains highly specialized receptor organ known as muscle spindle (Proprioceptor) which is very sensitive to a slight stretching of the muscle.

A simple example of a stretch reflex is the knee jerk. A subject is seated in the chair by crossing one leg over the other and the upper leg is kept loose. The quadriceps muscle on the front of the thigh remains slightly stretched. Now a tap on the patellar tendon just below the knee cap stretches the quadriceps a little more which makes the muscle to contract reflexly and the leg moves forward with a sharp and quick jerk.

The muscle spindle when stimulated by such stretching sends impulses (information) to the sensory neurone in the corresponding part of the spinal cord through sensory nerve fibres (see Fig. 9). The sensory neurone synapse directly with motor neurone in the spinal cord. An order to contract is passed on to the muscle through a motor nerve and the muscle contracts. Thus it is the protective mechanism for the muscle.

Muscle tone is an example of simple stretch reflex as the muscle is stretched between the bones and in a reflex develops a contraction to keep necessary basic tension in the muscle.

Although the peripheral nerve to the muscle carries both sensory and the motor nerve fibres to the spinal cord, they get separated outside the spinal cord before entering in it. The sensory nerve fibre emerges through the exterior nerve root. Of course these pathways are connected to the brain. The hamstring muscles (flexors of knee) relax to allow extension to take place in this stretch reflex action.

Tendon Organ

This is another type of receptor (proprioceptor) in the tendons of skeletal muscles. Sensory nerve fibre divides into a number of branches each ending in a small knob like structure. Tendon organ acts as a safety mechanism for stretch reflex, stopping further contraction of the muscle if the tension is rising too high. Stretching of the muscle results into its reflex contraction thus increasing its tension. If this tension rises excessively the muscle or tendon might be ruptured or torn if the tendon organ did not come into action to inhibit the stretch reflex.

Isometric Contraction

When the muscle is not free to shorten the contraction merely causes an increase in tension.

Length of the muscle does not change noticeably but the tension is developed. This is known as isometric contraction of muscle. This happens when muscle contracts against strong resistance. Best example would be the bullworker. One has to push both the ends of this instrument or pull the cords and maintain the position for some time. If the muscle is exercised in this way, it becomes bulky and stronger but there is no increase in endurance which may even be reduced because there is no increase in blood supply to this bulky or large muscle. An attractive manly shape is given to the muscle which is required only for the title of 'Mr. India' or to exhibit.

In older people isometric exercises are useless and dangerous as they cause considerable rise in heart rate and blood pressure which may rupture the weak arteries.

The isometric contraction, however, helps us to maintain a steady posture. In this muscular contraction less heat is produced than the isotonic muscle contraction as the muscle does not become shorter. The mechanism of these two types of contractions is otherwise similar. Perspiration is also comparatively less in isometric contraction.

Isotonic Contraction

When a contracting muscle is free to shorten i. e. it is not working against any resistance, it becomes short and an easy movement of the body part occurs. Thus the normal movements of the body are initiated by the isotonic contractions. In this contraction the tension

dose not increase but more heat is produced with the profused perspiration. All warming up exercises involve this type of muscular contraction. Running, swimming, drill are few examples. These isotonic exercises increase the stamina and endurance of the individual.

A knowledge of these two types of muscular activities is essential so as to understand the mechanism of asana, which is slightly of different nature. We would consider this point later on.

Any complex muscular activity involves finely coordinated isometric and isotonic muscle contractions. We cannot make them out separately. We can however judge the percentage of these two in a given muscular activity.

Muscular Fatigue

Frequently repeated contractions or sustained contractions of muscle result in a muscular (physical) fatigue as the supply of energy is fully consumed and lactic acid is accumulated. If the supply of O_2 or more correctly, the supply of blood is adequate and prompt, the onset of muscular fatigue is delayed. In muscular fatigue the strength of muscular contraction decreases and contractions become slower. Short but intensive physical strain also develops the muscular fatigue rapidly if the muscles are not previously trained. Muscular efficiency also depends on the work load and the duration of work. When a muscle is completely fatigued it fails to respond to the further stimulation and ceases to work. In such conditions proper rest, relaxation and glucose are

immediate requirements besides the oxygen. No doubt other systems like cardiovascular, respiratory and endocrine also contribute to the working capacity of the muscles. Systematic physical training improves endurance, strength, vigour and thus the health.

Oxygen Debt

During very strenuous muscular exercise, the rate of energy expenditure exceeds the rate at which oxygen can be provided to the active muscle resulting in an oxygen debt. Lactic acid is formed and accumulated in greater amounts as it cannot be disposed of from the muscles easily. So the oxygen debt is the amount of oxygen required to reconvert lactic acid formed due to anaerobic metabolism of pyruvic acid. We know that after a heavy exercise, increased breathing rate and depth is maintained automatically for sometime even after the cessation of exercise.

NERVOUS SYSTEM

Main function of the nervous system is to regulate the activities of the different organs and of the entire organism. This **neural base** is responsible for moment to moment adjustment, immediate coordination and communication with the internal and external environment from where the stimulations are constantly coming, thus responding quickly to sudden change. The nervous system links the various organs and systems, coordinates their functions and brings about the integrity of the organism.

A change in the function of one organ or system

leads to the changes in the functions of other organs or systems. For example during the vigorous muscular work, large quantities of CO_2 are produced which must be brought to the lungs to be thrown out of the body.

It requires the rapid blood circulation and rapid respiration. This necessity is communicated to the centres in the brain and these in turn issue the orders to the organs of circulation (heart) and respiration (lungs, diaphragm) to work more intensively. The flow of blood to the muscles increases. At the same time the excretory organs work hard, heat production and loss of heat increases. All these rapid changes are brought about by the nervous system.

Nervous system perceives all the external stimulations through the sense organs. In response to these stimulations necessary changes are brought about in the bodily functions and the organism adapts itself to its surroundings.

The nervous system includes the brain, spinal cord and nerves. For our convenience it may be divided into two divisions (1) the central nervous system and (2) autonomic nervous system which is further divided into two parts (1) sympathetic and (2) parasympathetic nervous systems.

The **central nervous system** consists of the brain, spinal cord, 12 pairs of cranial nerves arising from the brain and 31 pairs of spinal nerves. These nerves give off branches to the different organs and

tissues. The nerves and their branches constitute the **peripheral nervous system**.

The brain and spinal cord are large masses of nerve cells, their processes and neuroglia cells. Brain is well protected in the skull. Spinal cord which is elongated in shape is a prolongation of the brain and is held securely in the hollow of the spinal column. The brain and spinal cord are composed of grey and white matter. The **grey matter** consists of nerve cells while the **white matter** consists of nerve fibres which are the processes (axons) of the nerve cells. In spinal cord the grey matter forms the inner part which is surrounded by the outer layer of white matter. In brain it is just reverse, gray matter forms outer part and white matter lies inside.

All the nerves, coming from the brain and the spinal cord, spread themselves throughout the body and form a loosely woven network all over the body. Not even a pin-point area of the body is left without the nerve ending. Nerve, at its origin, is connected with a group of nerve cells which has a specialised function and is known as nerve centre. Nerves are thread like structures made of fibres (processes of nerve cells) with an outer connective tissue covering (insulation). Some nerves mainly consist of motor nerve fibres and are called motor or different nerves which carry the impulses of order from the nerve centre to the organs for action (e. g. muscle). Second type of nerves consists mainly of sensory nerve fibres and are known as sensory or afferent nerves which carry the impulses of information

to the brain. The ending of sensory nerve is called receptor which receives the stimulation. In the brain or nerve centres these impulses are interpreted into sensations. e. g. The sensation of smell, touch, taste, sound, and sight. There are also nerves which include both motor and sensory nerve fibres and are known as mixed nerves.

Generally speaking, there are two types of principal nerve impulses which form the basis of any nervous function. 1) **Inhibitory impulse** which starts the process of inhibition (stopping the function) and 2) **Acceleratory or excitatory impulse** which excites or accelerates or starts the function. For example, the flexion of an elbow requires a proper balance in these two types of impulses in order to contract biceps and to relax triceps of the arm at the same time.

The brain and spinal cord are constantly supplied with fresh blood as they need uninterrupted supply of nutrients and oxygen. Injury to the brain, spinal cord, nerve or a disturbance in the blood supply results in impairment of various bodily functions.

Cerebrum

It is the physical basis of mind. There are two cerebral hemispheres, the right and the left. The two hemispheres are linked by the corpus callosum which consists of nerve fibres. Outer part or the layer of the cerebrum composed of gray matter is known as **cerebral cortex**, having motor and sensory areas. Cerebral cortex is highly developed in man and is the highest part of the

nervous system regulating all functions of the organism by linking the individual with the external environment. Its surface has been increased due to convolutions or folds. It receives numerous sensory nerve impulses, especially from the surface of the body and from the special sense organs and it correlates this information and initiates appropriate motor responses. Consciousness, intelligence, memory, thinking, imaginations, reasoning, instincts, emotions, speech, analysis of sensory information are the main functions of the cerebral cortex. White matter of the cerebrum is nothing but the numerous nerve fibres which connect it to the other parts of the brain. Cavities within the cerebrum are called **ventricles** which contain **cerebrospinal fluid**. There are separate centres in the cerebrum for hearing, sight, speech, taste, etc. and the interesting thing is that left hemisphere controls the activities of the right side of the body and right hemisphere controls the left side. Damage to a particular area of the brain affects a particular activity of the body.

Cerebellum

It is located behind the medulla oblongata and pons and below the posterior side of the cerebrum. It has two lobes and a middle part called vermis. Like cerebrum the grey matter forms the external layer (cortex) and white matter lies inside. Cerebellum is well connected with cerebrum, pons, medulla oblongata and other parts of the brain.

Activities of the cerebellum are of a reflex character. Though the voluntary movements are initiated by

he cerebral cortex (by desire), their efficient performance depends on the cerebellum. Cerebellum is engaged in co-ordination, distinctness and smoothness of the movements whenever the information about the movement and the position of the body in space reaches to it. It also predicts the future course of movements with the help of cerebrum and maintains the muscle tone. It has got an important role in maintaining bodily balance in space. Walking, running, dancing, speech, and all appropriate movements are concerned with the cerebellum.

Medulla oblongata and the pons constitute the brain stem. It contains the network of nerve cells and nerve fibres and it is engaged in reflex function and conduction of ascending and descending impulses. It contains vitally important centres of cardiac activity, respiration, vasomotor activity, digestive activity (salivation, secretion of gastric juices etc), defence reflex (coughing, vomiting, etc.). Thus it controls respiration, heart function by reflex actions. Functions of medulla oblongata and pons are influenced by the cerebral cortex and other parts of the brain.

Hypothalamus

It is an important centre of autonomic nervous system to regulate many activities of the body like metabolism, heat production, heat loss, arterial pressure, cardiac activity, activity of pituitary gland. It is engaged in wide spread effects of emotion through the autonomic nervous system.

Cranial Nerves

There are twelve pairs of cranial nerves. Some of them (first, second and eighth pairs) are sensory, some (third, fourth, sixth, seventh, eleventh, and twelfth) are motor nerves and still others (fifth, ninth and tenth) are mixed nerves. The cranial nerves mainly innervate the organs in the skull (eyes, ears, nose etc.) while the tenth pair (vagus) also innervates visceral organs like oesophagus, lungs, heart, liver, etc. and control their activities.

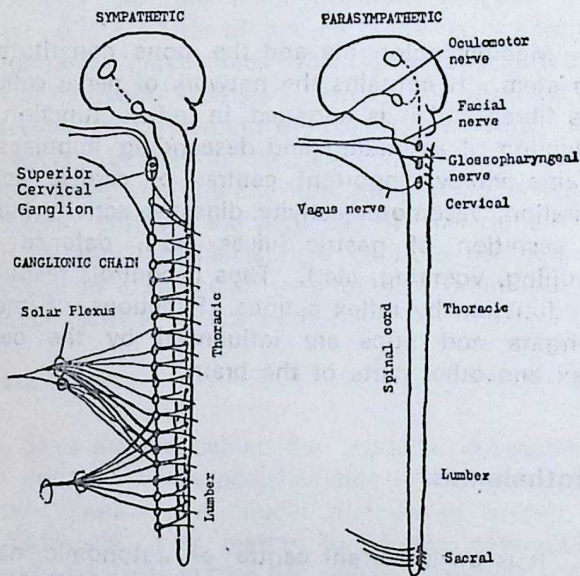


FIG.11 VEGETATIVE NERVOUS SYSTEM

Spinal Cord

The spinal cord is very well protected inside the

vertebral canal. It starts after medulla-oblongata, passes through the spine and goes right up to the end of the spine. On its anterior (Front) side and the posterior (back) side run longitudinal fissures which divide it incompletely into symmetrical halves, (see fig 9 & 12). In the spinal cord the grey matter lies inside and the white matter is outside. There are two anterior projections, the ventral horns and two posterior projections, the dorsal horns from the spinal cord. Ventral horns contain motor nerve cell while dorsal horns contain internuncial neuron for effective communication between sensory and motor nerve cells. Sensory nerve cell is located outside the spinal cord forming spinal ganglia. From ventral horn, the anterior root starts which contain motor nerve fibres while the posterior root which starts from dorsal horn, contains sensory nerve fibres.

The nerve fibres are grouped in tracts or nervous pathways. Some tracts are ascending (sensory) and some tracts are descending (motor). Motor and sensory roots merge with each other and form the spinal nerve. A pair of spinal nerves emerges between the two vertebrae (intervertebral foramen). There are 31 pairs of spinal nerves i. e. eight cervical, twelve thoracic, five lumbar, five sacral and a coccygeal.

Main functions of the spinal cord are : 1) Conduction of nerve impulses and 2) Reflex activity. The nerve impulses, transmitted to the spinal cord from different organs or parts of the body are now conducted along the crossed sensory tracts and then along the ascending nervous pathways to the brain where the sensation is felt. Motor nerve impulses are transmitted from the

brain to the spinal cord along the descending pathways and then along the crossed motor fibres and through the spinal nerves to the respective motor organ to initiate the action. The functions of the spinal cord are however regulated by the brain.

The Reflex Action

The reflex action is the physiological unit of the central nervous system. The spinal cord contains reflex centres of various functions at different levels such as muscular activity, movement of the diaphragm, perspiration, urination, defaecation, activity of the sex organs etc.

Reflex action is the sudden reaction of the part of the body or the body as a whole in response to a sensory nerve impulse sent by the receptor with or without the involvement of the consciousness.

When the sensory nerve ending i. e. receptor is stimulated, it initiates the impulse which travels through the sensory neurone, one or more internuncial neurones, motor neurones and along the motor nerve to the organ of action. This pathway or the circuit is known as Reflex arc (see Fig. 12).

The knee jerk is an example of a simple reflex action (page 30, 'stretch reflex') using lumbar and sacral regions of the spinal cord. Other reflex actions may be very complicated and require the help of nervous tissue in the brain i. e. Cerebellum.

If you happen to touch a hot plate unknowingly, the hand which touched the hot plate is quickly with-

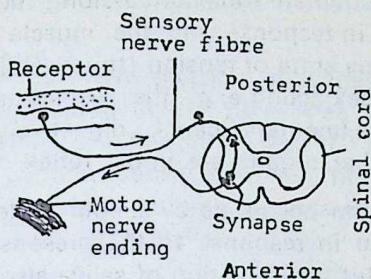


FIG. 12 REFLEX ARC

drawn. This is a simple reflex action but if by mistake your hand comes in contact with hot plate again and again, cerebellum and the higher nerve centres come to your rescue in this situation.

Sensory nerve carries the information from the receptor to the nerve centre in the spinal column. The impulse of action is sent in response, to the motor organ through the motor nerve. The motor nerve ends in the muscle it supplies, in the form of motor end plate. The impulse reaching this end plate causes the muscle to contract. It must be noted that the reflex action and rest of the nervous system are not separate. Depending on the intensity of the stimulation the necessary part of the higher brain is informed to take the right type of decision with consciousness.

Muscle tone is also regulated by the reflex action. Proprioceptors like muscle spindles, tendon organs,

when stimulated due to changes in position of joints, muscle etc. send impulses to the spinal cord. The impulses of action are transmitted along the motor nerve to the muscle in response and the muscle is maintained in a continuous state of tension (tone). Quick movements are due to reflex action e. g. the respiratory mechanism, functions of alimentary canal, digestive glands, heart and many other organs are under reflex control.

Salivation occurs as a simple reflex or **inborn reflex action** in response to the presense of food in the mouth. But the secretion of saliva also takes place in response to the sight or smell of appetizing food. This is the **conditioned reflex**. Even a scrind of the dinner bell or thinking of delicious food will stimulate the salivary glands. The conditioned reflex is an involuntary activity which depends on the cerebral cortex. It is developed by the repeated association of the inborn reflex with the stimulus which is abnormal or new for the nerve centre. The abnormal stimulus is interpreted by the cortex and if it is appropriate it will be adapted with the inborn (unconditioned) reflex. The process of learning is continuously helped by the conditioned reflexes. Conditioned reflexes are aquired during the life time of the man which are strictly individual and are not constant. They may disappear and appear again.

Autonomic Nervous System (ANS)

Sympathetic and parasympathetic nerves constitute the **vegetative or autonomic nervous system** (see Fig. 11). The **sympathetic** branch is mainly represented by two chains of ganglia placed on both the sides of the vertebral column (spine), in cervical, thoracic,

lumbar and pelvic region. Each of these regions has a certain number of ganglia which give off nerve branches to form the part of the vegetative nerve plexus.

Parasympathetic division of vegetative system includes nuclei located in the brain stem, ganglia and nerve fibres. Third, seventh, ninth, and the tenth pairs of cranial nerves contain parasympathetic fibres. Also the sacral part of vertebral column possesses parasympathetic ganglia and nerve fibres.

Both sympathetic and parasympathetic nerve fibres innervate almost all the organs in the viscera and skull, e.g. Digestive organs, blood vessels, excretory organs, eyes, salivary glands, etc. It should be noted that the hypothalamic region of the brain contains higher vegetative nerve centres for ANS.

Life processes which are ever going on in our body without our notice or attention are all under the influence of vegetative nervous system, e. g. manufacture of bile in liver, metabolism, secretion of pancreatic juice, beating of heart, micturition (passing of urine), defecation (passing of faeces) and parturition in females (giving birth) etc.

The two divisions of ANS are mutually coordinated for the smooth functioning of the organs. Stimulation of sympathetic nervous system dilates the pupils, decreases the secretion of salivary and lacrimal glands and constricts the small arteries and veins but dilates the coronary arteries of the heart, elevates blood pressure,

increases heart rate, slows down intestinal peristalsis, decreases secretion of gastric glands, relaxes bronchial muscles reduces heat loss etc. Stimulation of the parasympathetic division causes opposite phenomena. It constricts the pupil, encourages the secretion of the salivary and lacrimal glands, slows down the heart, increases intestinal peristalsis, excites secretion of gastric glands, constricts bronchi, dilates blood vessels, increases heat loss etc. ,

In short the sympathetic system prepares the body for physical activity (e. g. in case of fear as the defence mechanism) while para-sympathetic activity restores resting conditions after the physical activity or emergency is over. Thus the autonomic nervous system is influenced by various emotional states of the individual e.g. love, hatred, fear, depression etc. It is also influenced by certain hormones. For example adrenalin can raise the tone of sympathetic system. The activity of ANS is regulated by the hypothalamus in the brain, and a very fine functional balance is maintained in these two divisions of ANS for a normal work. This balance is known as autonomic balance. This balance gets disturbed due to certain factors like emotions, hormones etc.

CONSCIOUSNESS AND AWARENESS

Nerve impulses from sensory organs reach the cerebral cortex and arouse the sensation. The nature of each sensation is analysed and interpreted in appropriate region of cerebral cortex. The individual must be conscious in order to experience the sensation.

The Reticular Formation which is mainly responsible for this arousal of the brain, is the extensive network of mixed gray and white matter. It contains many important 'centres' like cardiac, respiratory centres etc. It has connections with descending and ascending tracts. It is an important relay station to pass the ascending sensory impulses to the thalamus and the cerebral cortex. Direct connection of these impulses to the cortex is responsible for the awareness and the connection through the thalamus arouses a particular region of cortex so that the attention is diverted to the nerve impulses reaching it. When there are few sensory stimuli, few impulses reach the reticular formation and the number of impulses are thus reduced, the arousal mechanism fails and sleep sets in. Sleep is a normal physiological function of animals and man. It is due to the inhibition of the cortical activity. When the reticular formation is again excited, sleep is replaced by wakefulness.

The stimulation coming from the external environment through **exteroceptors** (Sense organs—Dnyanendriyas) develop the external awareness. While the stimulations inside the body (Internal environment) also influence the reticular formation and arouse internal awareness. The awareness of the internal environment depends on the interoceptors i. e. 1) Proprioceptors like muscle spindle, ligaments, joints, tendons and vestibular organs etc. and 2) Visceroceptors i. e. sensory nerve endings in the walls of stomach, blood vessels urinary bladder, lungs etc. Usually we remain aware of the external environment and rarely pay attention to the internal processes. We become aware of the visceral organs due to the sensation of pain, heat, pressure, hunger,

throbbing etc. from them. We also become aware due to the particular emotional things, thinking, desires and intellectual analysis. If the external disturbances are cut off we get inner awareness. Simple example may be given that when we close our eyes we can pay better attention to the internal things and can concentrate better on the internal mechanism like breathing. Most of the sensory nerve impulses involved in posture and involuntary movements or functions are concerned with reflexes. Only a small portion of them evoke sensation.

Stimulation of the receptor.

Impulse passed through a sensory nerve.

Sensory area of cerebral cortex.

Sensation, perception (State of consciousness)

Attention to the particular sensation.

Awareness

Sensation is the translation of a sensory impulse coming from the excited or stimulated receptor. If the sensation is analysed and interpreted in the light of previous experience it is known as **perception**, which is the function of the cerebral cortex, e. g. particular

visual pattern of sensation is interpreted as 'Tree'. Sensations and perception are important in our communication with the external environment. We can understand the sensation in the following terms. 1) **Nature** e. g. pressure, temperature, movement, stretching, suction, throbbing etc. 2) **Region** or location in the body where it is felt. 3) **Intensity** i. e. whether the sensation is mild, strong or acute and 4) **Duration** or the period of sensation i. e. short or prolonged period or time.

The potentiality to experience peculiar type of sensations due to stimulations of interoceptors is developed by constant practice of Asanas, Pranayamas, Omkar, Dhyan etc.

ENDOCRINE SYSTEM

This system works hand in hand with the nervous system in order to coordinate the functions of various systems of the body. It consists of glands having no ducts to pass their secretion. Their secretion is known as **Hormone** which is poured directly into the blood stream. Hence these are also known as **ductless glands**. Hormones are chemical substances which act directly on particular tissues to influence particular biological process. This **chemical base** is responsible for the gradual but permanent or long term adjustment with the environmental conditions (stimulations). The balance in the secretion of various types of hormones is maintained by the nervous system and the hormones in their turn affect the functions of different parts of the nervous system. Thus these two systems cooperate with each other (feed back mechanism) to maintain the physiological balance-**Homeostasis**-constantly in the internal

environment of the body. It has been experimentally proved that (since these hormones act on the nervous system) they are also responsible for a particular behavioural pattern, mood or temperament or psychological make up of the individual. This constitutes another branch of science known as 'Psychoendocrinology' e. g. Behaviour of a female at the time of puberty or menopause.

If these secretions suffer in quality & quantity due to under (Hypofunction) or over (Hyperfunction) activity of the glands, some pathological conditions in different parts of the body are rapidly established e. g. due to malfunction of thyroids the hair begin to grow gray, the nails become brittle, fatty degeneration starts in the arteries and so on.

Principal endocrine glands, their hormonal secretions and functions are as follows :

1. Pituitary Gland : Pituitary gland (hypophysis) is a small structure like a pea, located in the cranial cavity at the base of the brain and is connected with the hypothalamus by a stalk. It has two lobes 1. **anterior lobe** and 2. **Posterior lobe**. The anterior lobe secretes six hormones. Growth hormone (GH), Milk producing hormone (in females), thyroid stimulating hormone, Adrenocorticotrophic hormone (ACTH) which stimulates adrenal gland and thus influence sugar and fat metabolism, Gonadotrophic hormones which influence the sex glands and the hormones influencing other glands.

The posterior lobe secretes **oxytocin and vasopressin** hormones. Oxytocin acts on smooth muscle,

particularly on the uterus during labour. Vasopressin is anti-diuretic in action, regulating the urine formation by increased water absorption in kidneys so that less urine is produced. It also acts on the arteries causing contraction of them and corresponding rise in the arterial blood pressure.

2. Thyroid Gland : It lies in the neck in front of the trachea just above the vocal organ. Its hormones **thyroxine, tri-iodothyronine** and **calcitonin** accelerate metabolism in the body and increase concentration of glucose in the blood. They help the normal growth of the body by proper deposition of calcium in the bones etc. **Hypothyroidism** (lack of thyroid activity) makes the children physically and mentally retarded (cretinism). In adults this under-activity causes myxoedema. Patient becomes sluggish, weak, obese and nervous. Over-activity of the thyroid produces exophthalmic goitre in adults with increased heart rate, protruding eyes, loss of weight, swelling in the neck, tremors etc. Proper medical help can avoid these conditions and can control the thyroid activity.

3 Parathyroid glands : These are four small pea-shaped glands lying behind the thyroid glands. Their hormone increases the calcium level in the blood by removing it from the bones.

4. Adrenal or Suprarenal Glands : These are two small cup-shaped structures one on the top of each kidney. Outer part (cortex) and inner core (medulla) differ from each other in structure and function. Adrenal cortex produces number of hormones like aldosterone

cortisol, androgen, oestrogens and progesterone. These hormones (steroids) control the water balance in the kidneys, govern secondary sexual characteristics e. g. beard in males, breast development in females etc.

Adrenal medulla produces adrenaline and noradrenaline hormones. Adrenaline is secreted in the emergency or sudden stressful conditions and supplements the action of sympathetic nervous system by increasing the heart rate and its force, raising blood sugar level (from liver) and metabolic rate, reducing the movements of alimentary canal etc. Thus it prepares the individual for defence or attack. Adrenaline constricts blood vessels except those in skeletal muscles and heart, which it dilates.

5. Islets of Langerhans : These are scattered group of cells in pancreas and secrete insulin and glucagon. **Insulin** lowers the blood sugar concentration while **glucagon** raises it. Body tissues cannot use sugar without the help of this hormone which permits the transport of glucose from the blood stream into the cells. Lack of insulin in blood causes **Diabetes mellitus**. The patient passes large volumes of urine frequently, becomes thirsty, feels hungry all the times and blood sugar level rises high which is dangerous for his life. The excessive sugar then appears in the urine which is absent in the normal urine.

6. Gonads : Apart from the function of production of sperms and ova, the testes (in males) and ovaries (in females) respectively, produce hormones from their en-

doocrine cells. Testes produce testosterone which promotes the development of muscles for their particular manly shape and size, growth of penis, hair, change in voice, and development of the male personality.

Follicular cells of the ovaries and when the ovum is shed the remaining follicular cells—corpus luteum perform endocrine function. They produce oestradiol and progesterone respectively. Oestradiol is responsible for broadening the hips, development of the breasts, distribution of hair, particular voice and thus develops the female personality. progesterone is helpful in pregnancy which prevents normal menstrual cycle, inhibits contractions of uterus etc.

SKELETAL SYSTEM

The bones and their articulations form the **Skeleton** of the body. Skeleton consists of the skull, the backbone, ribs, bones of the hands, legs, shoulder and hips. Skeleton is the frame-work of bones which supports the muscles and other softer parts of the body. It also wonderfully protects our brain, spinal cord, heart, and lungs. Brain is well secured in the skull and spinal cord is safely lodged in the hollow of the backbone (spine). The skeleton also helps in movements of different body parts and the body as a whole. Skeleton gives a definite form, shape and position to the body in space.

Bones are the hardest parts of the body and form the basis of the physical structure. Each bone is supplied with nerves, blood and lymphatic vessels. The bone

marrow lies inside the bones. There are red and yellow types of bone marrow. The red bone marrow produces blood cells. Muscles are attached to the bones. In fact bones remain passive during the movements.

Generally speaking there are four types of bones (1) **Flat** (in skull), (2) **Irregular** as in spine, (3) **Small** as in fingers and (4) **Elongated** as in hands and limbs. Human body consists of about 206 bones.

Bones are joined together by means of joints most of which allow their movements within a particular limits. The joints or the articulations are classified as follows.

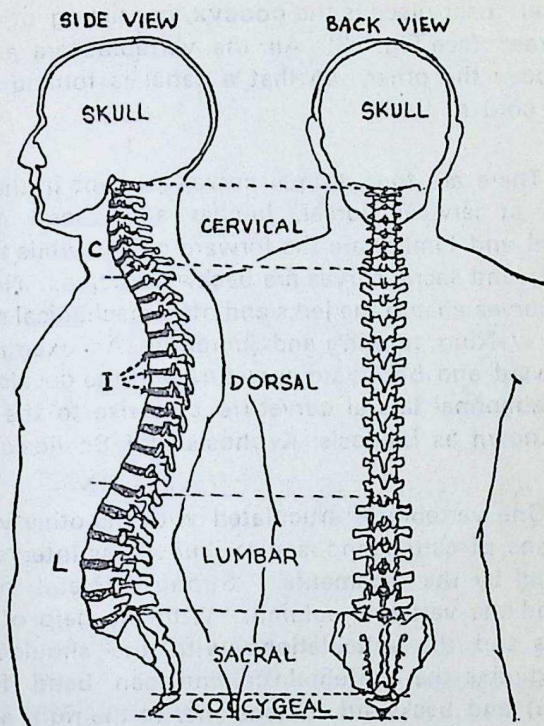
1. **Immovable joint** : The bones are united by the cartilage (e. g. Ribs and sternum) and fixed with each other. Skull bones which are flat, unite by interlocking system.

2. **Slightly movable joint** : Here the bones are united by the ligaments with fibrous cartilage in between e. g. joint between the vertebrae.

3. **Freely movable joint** : The bones are connected by a fibrous capsule. There are many types of freely movable joints e. g. elbow, knee, wrist, fingers and shoulder joints. Joints are lubricated by a fluid substance, secreted by the membrane of the capsule.

Vertebral column (spine) consists of 33 pieces of bones, each piece being called a **vertebra**. First seven vertebrae are situated in the neck (cervix) and hence are

called **Cervical vertebrae**. Twelve vertebrae are located in the thorax, in the region of the back, known as



C - Cervical Curve

I - Intervertebral Disc

L - LUMBER CURVE

FIG. 13 VERTEBRAL COLUMN

dorsal or **thoracic vertebrae**. The next five are **lumbar vertebrae** which are largest in structure. **Sacrum** starts after lumbar part consisting of 5 vertebrae, fused together. Last piece is the **coccyx**, consisting of 4 fused vertebrae. (see Fig. 13) All the vertebrae are arranged one above the other, so that a canal is formed for the spinal cord to lie in.

There are four normal curves present in the spine namely at cervical, dorsal, lumbar and sacral regions. Cervical and lumbar are the forward curves while thoracic (dorsal) and sacral curves are backward curves. Normally these curves absorb the jerks and offer mechanical support during walking, running and jumping. An exaggeration of forward and backward curvature and the development of an abnormal lateral curvature give rise to the conditions known as Lordosis, Kyphosis and Scoliosis.

One vertebra is articulated with the other vertebra by means of cartilagenous disc, known as intervertebral disc, and by the ligaments. Strong skeletal muscles surround the vertebral column. With the help of these muscles and the articulations with the shoulder and pelvic girdles the vertebral column can bend forward (flexion) and backward (extension), to the right and left sides (lateral flexion) and can also rotate in right and left directions (twisting), in the vertical axis (see Fig. 14).

Shoulder girdles with the help of strong skeletal muscles, connect arm bones to the thoracic part of the vertebral column. Pelvic girdles are articulated with the sacral part of the vertebral column and the leg bones.

Ribs are attached to the thoracic vertebrae, on the dorsal side and the breast bone (sternum) in front. There are

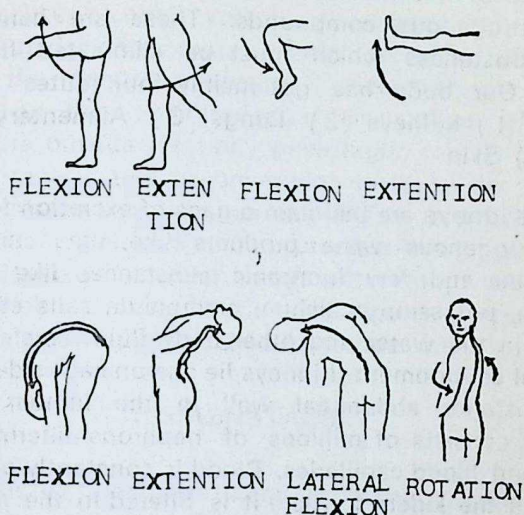


FIG. 14 SOME BASIC MOVEMENTS

12 pairs of ribs which form the thoracic cage. Ribs and clavicle bones move with the help of intercostal muscles during inspiration and expiration, to increase and decrease the diameter of the chest respectively.

EXCRETORY SYSTEM.

During the continuous process of metabolism simple products of digestion are built up into the complex molecules of living matter (tissue building or ana

bolism) and the complex molecules are broken down to release energy (cell destruction or catabolism). The end products of this metabolism are carbon-di-oxide, water and nitrogenous compounds. These are harmful or toxic substances which must be eliminated from the body. Our body has got mainly four routes of excretion. 1) Kidneys 2) Lungs 3) Alimentary canal and 4) Skin.

Kidneys are the main organs of excretion for water and nitrogenous waste products like urea, uric acid, creatinine and few inorganic substances like ions of sodium, potassium, calcium, ammonium salts etc. They maintain the water and other body fluid levels in the internal environment. Kidneys lie one on each side against the posterior abdominal wall in the lumbar region. Kidney consists of millions of nephrons—filtering units of it and blood capillaries. Blood is constantly circulated through the kidneys where it is filtered in the nephrons and sent back to the heart. The blood is now free of toxic substances. The urine thus formed in the kidneys is passed down to the urinary bladder through ureters. At the time of micturation the bladder contracts and expels urine through the urethra which passes through the penis in males and opens up above the vagina in females. Normally on an average we excrete 1.5 litres of urine in 24 hours which however depends upon the water intake and the environmental temperature etc. Specific gravity and the colour as well as the constituents of the urine are affected in pathological conditions. Urine could be tested in the laboratory to detect such diseased conditions. We have a voluntary control over the emptying of bladder, which we gain right from our childhood.

Lungs eliminate carbon-di-oxide during the expiratory phase of each respiration. The water vapour is also excreted along with the expired air. Thus any volatile substance like alcohol, volatile anaesthetic substance, are eliminated by this route. **Skin** secretes salt and water in the form of 'sweating'. Secretion of sweat depends on the environmental temperature. If the temperature outside the body goes high, or even when the body temperature becomes high in fever, the heat is lost through the sweating, thus cooling the body. **Alimentary canal** eliminates some bacteria, bile pigments and other indigested colouring agents etc. along with the faeces which consists of residue of digestive secretions, undigested food materials and very little water.

HOMEOSTASIS

Thus our body has many different organs, each performing a specific function for the body. For the normal function of the body, coordination of the functions of all these organs is essential in both, during resting conditions and during active exercise. The activities of different systems are adjusted to the demands of new situations. This coordination of activities for efficient function of the body is achieved mainly by two controlling systems, the endocrine and nervous systems.

Our body functions can take place only in a particular internal environment. A balance which is maintained in this internal environment is known as homeostasis. It is an active process by which the constant hydrogen

ion concentration, proper supply of nutrients, removal of waste (toxic) products of metabolism etc. are maintained without our notice. Temperature of the body is kept constant at about 37°C (Thermoregulation). If the temperature of the body rises too high or comes down too low, then the body cells are unable to work. These cells are continuously bathed by the tissue fluid which is in contact with the circulating blood. Cells absorb their nutrients and oxygen from this tissue fluid and give up the waste products in return. The blood which is constantly circulating, acts as a transport system to supply nutrients and oxygen to these tissues and to carry the waste products back to the organs of excretion, via heart. The blood picks up more food from the alimentary system and oxygen from the respiratory system and eliminates the waste products, gathered from different tissues, through the excretory system. A constant pH of blood or the hydrogen ion concentration in blood is continuously maintained in this homeostasis because the cells cannot survive if the medium (blood, tissue fluid) becomes even a slight acidic. Protein, bicarbonate and phosphates act as 'buffers' so that the blood pH is maintained at 7.4 i.e. slightly alkaline in nature.

Endocrine system provides the chemical (base) substances - Hormones which influence the various processes slowly and bring about a gradual change. This forms the basis for the nervous system. Nervous system governs almost all the bodily functions through different reflexes and rapid responses to environmental stimulations. It provides a fine defence system also. It coordinates all the systems together. If all these sys-

tems cooperate each other perfectly, the harmonious-physiological functioning is ensured. This harmony in all the functions of the body is nothing but the health. All the functions are at optimum level. If this balance is disturbed, disease sets in. So the objective of yogic practices on their physical side is to avoid disease and to promote health by establishing and maintaining such physiological harmony in the human body.

POSTURE

In order to understand what is an asana, let us know what is a posture. This term is often applied to explain an asana. A good knowledge about posture, its formation and control would give us fair idea about asana. In fact any asana would contain some or the other bodily posture.

Erect (standing) posture, sitting posture and a lying posture are the three basic postures which are characteristics of human body and have been developed during the course of evolution.

Posture may be defined as the particular position, assumed by the body with or without the external support. Any posture would involve a well co-ordinated action of several muscles. Generally a posture is acquired for stability and equilibrium of the body which

forms an essential basis for some movement which is superimposed on it. e. g. Sitting in a chair adapted for writing.

Efficient Posture

An efficient posture is that which fulfils the purpose of the specific activity for which it is assumed, economically. Economical in the sense, it should involve minimum amount of voluntary muscular efforts for its maintenance and adjustment. This is a very easy job for the body provided the muscle tone is adequate and all other mechanisms involved are co-ordinating in a healthy manner. Posture would be good posture if the centre of gravity passes exactly from highest point of the skull, and through cervical and lumbar vertebrae, through the centres of the hip, knee and ankle joints. The whole weight is thus well balanced and the body is not bending forward or backward. Such posture is normally maintained without our attention.

Many persons due to their particular postural habits in standing, sitting and lying conditions develop defective posture where undue weight falls outside the body in front or back. Four natural spinal curves are disturbed and Lordosis (lumbar region coming forward) or kyphosis (excessive dorsal bent) or right or left sided scoliosis may be developed. It becomes permanent and more exaggerated as the age advances. It can be corrected in early stages of life with a well planned exercise programme and good habits. The foundation of good postural habits should be laid before the age of twenty.

Mental characteristics are also associated with the bodily structure and posture. A good posture exhibits a sound mental and physical health. A particular posture can express the attitude or the nature of the individual. Different moods, temperaments, emotions and psychological factors do affect the erect or sitting posture as the muscle tone is influenced by them.

Control Of Posture

A finely coordinated control of the skeletal muscles is involved in the formation and maintenance of the posture. This is done by the motor nerve impulses from the central nervous system. This is known as neuromuscular coordination. It depends in turn on sensory impulses (moment to moment information) coming from the skin, eyes, ears (exteroceptors) and the interoceptors such as muscle spindles, tendon organs, joint organs and labyrinth (proprioceptors) and visceroreceptors. They convey the information about the position, movement and balance of the body. These impulses are received, integrated and correlated in the brain below the level of consciousness (i. e. no activity of the cortex) and appropriate motor impulses are passed on to the concerned muscle (see Fig. 15), for action. This is involuntary control of the posture and movement.

In short, various reflexes set by receptors e. g. stretch and pressure reflexes etc. bring about the proper contractions in the skeletal muscles and maintain the posture. These are known as **Postural reflexes**. The extensors and flexors of the neck, lower limbs and the trunk, hip muscles are the main muscles of posture

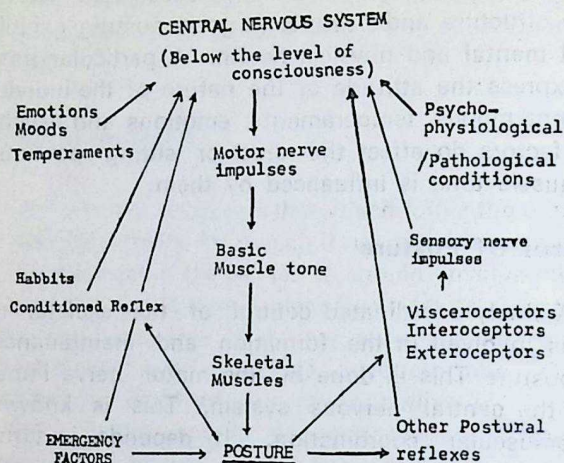


FIG. 15 CONTROL OF POSTURE.

which balance the body against gravity. These muscles are alternately stretched due to the weight of the body and results in the reflex contractions and thus support the body weight. Once the posture is adopted for particular purpose, it is maintained and constantly adjusted or modified due to the **postural reflexes**. During the movement the relative position of the limbs and trunk are constantly adjusted to maintain an equilibrium of the body.

Voluntary movements are initiated by the motor nerve impulses arising in the motor areas of the cerebral cortex. These impulses pass down through the spinal cord and after reaching the particular muscle, bring

about the muscle action. Coordination of these voluntary actions of antagonists, agonists and other muscles, as well as the prediction of future movements and positions depend on cortex and cerebellum.

Classification of Posture :

Postures can be classified broadly into (1) Inactive postures and (2) Active postures. Active postures can again be divided into (a) Static and (b) Dynamic postures.

1) **Inactive postures** are generally adopted for resting or sleeping. There is a general relaxation of all the musculatures, except those which are required to maintain life e. g. respiration, blood circulation. These activities are also reduced to a minimum. For example, resting in lying supine or recumbent position in easy chair where there is no question of muscular efforts against gravity.

2) **Active postures** are those in which some neuromuscular coordination or efforts are required for their maintenance which may be voluntary or involuntary.

a) **Static Posture** is that in which the type of posture adopted, is stably maintained for some time by the coordinated inter-action of muscles. Various joints are stabilised and a state of equilibrium is preserved against gravity and other forces. It is controlled involuntarily if one is not aware of the posture he has assumed. Such posture (e. g. sitting comfortably) may be maintained in semi-relaxed state.

b) **Dynamic Posture** : is that which is constantly modified or adjusted to meet the changing demands of

the movement which is superimposed on it. Muscles work against gravity in order to maintain the equilibrium of the body. In fact almost all these varieties of postures are included in different types of asanas.

Thus it will be seen that the whole approach in studying the basic principles of anatomy and physiology is to understand the probable mechanisms involved in various yogic practices, on the scientific ground. It must be clear that our body responds according to the nature of stimulations from external or internal environments. Yogic practices work deeply inside the body and mind and are expected to bring about some changes even in the normal individual so as to prepare him to advance on the path of Yoga. Therefore our yogic techniques should have the scientific back-ground along with the traditional support.

This scientific background would also help an individual to remove confusion or misconception if any, regarding the technique of the yogic practice. He would then be the best Yoga teacher to guide his students on the path of yoga,

PART TWO

ANATOMY AND PHYSIOLOGY OF YOGIC PRACTICES

ĀSANA

Literally asana means a 'sitting-posture' or 'position' of the body which contributes to the steadiness of body and mind and a sense of well-being. The term asana is also used to indicate a carpet of grass or well tanned deer-hide which forms a comfortable 'seat' on the ground for sitting. Asanas occupy the first place in Hatha-yoga while they form the third item of Patanjali's ashtang yoga.

Asanas are often translated as 'postures' and therefore termed as Cobra posture, Crocodile posture, Bow posture and so on. It is true that many asanas do contain some kind of posture and bear most of the characteristics of posture. Yet asanas and postures differ in many respects and therefore the term posture does not explain fully the meaning of asana.

In posture, though it is maintained economically without much efforts, there is no consideration of the state of 'mind'. The state of mind may vary in different

postures. We relax in chair quite comfortably but we may be upset mentally due to a series of thoughts in this posture. Many postures are developed and maintained below the level of consciousness i. e. without our attention. For example, a sitting posture for writing or standing posture for threading the needle. Asana is acquired first voluntarily and then it may be controlled below the level of consciousness. Thought process is not allowed in asana. On the contrary a particular type of awareness is advocated during the maintenance of asana e. g. awareness of breathing etc., so that there is no mental disturbance. No movement is superimposed on any asana nor it is expected out of it. The movement for assuming the asana and to release it is also gone through in a special manner i. e. in a slow and smooth manner. The movements to achieve or to release any posture are not so important and may be in any manner. Standing, sitting or lying postures do not offer any special training to the muscles and the nerves involved in them. In asanas some special training is expected on both the physical and mental levels. Postures may be maintained with the help of external support e. g. sitting in a chair; but in asanas there requires no such support (except from the ground !).

Some times asana is also translated as pose but the term pose is also not suitable to explain the asana. Pose is not a natural position of the body. It may be an artificial one which is developed to express some emotion or thought. Asanas do not express anything. There is no expression even on the face during the practice of asanas. Pose, maintained for a couple of seconds, may lead to a physical or mental strain. Asanas do not cause

any exhaustion at any level. On the contrary there is a feeling of well being even after the practice of asanas is over.

The term 'Exercise' is also applied to asanas but it is not correct. Asana is not an exercise. Exercise may lead to an exertion. There is no purpose of body building in asanas like in exercise. The word exercise gives us an idea of quick and forceful movements of the body or its parts and their repetitions whereas asanas are more static in nature. No repetitions as well as the tension or fatigue are expected in asanas. We shall see the basic difference between asanas and exercises later on in details.

In the light of the above discussion the asanas can only be defined as the 'Postural pattern'. One has to achieve this pattern slowly, maintain for sometime steadily and to release it again in a slow and smooth manner. A gradual training is given to the whole body and mind through particular neuro-muscular mechanisms involved in different asanas. This is expected to bring about some specific changes gradually in the total personality of the individual. Thus it is the pattern of the posture involved in asana which is important and responsible to educate body and mind, and to prepare them for further yogic practices like Pranayama, Dharana, Dhyana etc. Movement part of it is not so important.

Two aspects involved in any asana are 1) Dynamic aspect and 2) Static aspect.

1) Dynamic aspect : While performing asanas some movement is essential in order to assume asana or to come back to the initial stage from asana. These movements should be very slow, steady, smooth and without any jerks so that there is no tension or fatigue. There is no undue stress or strain on breathing. Breathing is not controlled voluntarily in asanas. Generally it is allowed to be adjusted by the body itself during these movements.

2) Static aspect : Once the 'Postural Pattern' is assumed it is to be maintained for some length of time steadily and comfortably i. e. without any tensions in any part of the body. In this static aspect however the awareness of breathing, or of a large ocean is advocated to avoid any disturbance in the mind. Asana is again released after such maintenance, in a slow and smooth manner. We are going to study this static aspect in details under the heading 'mechanism of asana.'

Characteristics of Asanas

Here, we can quote Patanjali who gives us three very short aphorisms dealing with the principles of asanas, their objectives and effects and the mechanism through which these results are obtained. It may be stressed again that these mainly concern with the static aspect of asanas.

स्थिरसुखमासनम् ।

Sthira-sukham-asanam (Patanjali Yoga Sutras : II : 46)

This aphorism gives us an idea of the main characteristic feature of asana. It says, asana is that which contributes to stability and a sense of well being. Stability here does not mean the stability only of the posture but the stability of the body and the mind as a whole. Even if we are bodily stable in asana we may remain mentally unstable due to some disturbances. The stability of both body and mind together would lead to the sense of well being. It does not also mean that any posture which is easy to attain and stable to maintain is an asana. In that case perhaps, sleeping condition should be the best asana, being easiest and the most stable one. Since the word asana is related more with the sitting condition, i. e. a conscious state of mind, it cannot be a sleeping condition. Therefore a postural pattern leading towards bodily and mental stability and a sense of well-being, will be our asana.

प्रयत्नशैथिल्यानंतसमापत्तिभ्याम् ।

Prayatna shaithilya ananta samapattibhyam

(P. Y. S. II : 47)

This aphorism tells us how the above mentioned state can be achieved. Slackening of efforts and contemplation on the 'infinity' are two ways for reaching the above goal. In other words the relaxed condition or effortless maintenance of asana would make the mind free which is now allowed to be attached with the infinity. In short no mental activity is allowed which may otherwise be engaged in some thought processes and bring in tension. The mind is therefore withdrawn from the

body and shifted to the infinity to forget the body. The postural pattern is thus to be maintained below the level of consciousness as the awareness is directed and fixed to such a thing from where no stimulations are expected to come.

Of course this is rather difficult in the beginning even in case of meditative asanas due to the resistance offered by the body itself, and the wandering habits of the mind. One is advised to cultivate an oceanic feeling (Mahahradanusandhana) i. e. a feeling as if one is just a ripple or a drop of the vast ocean, during maintenance of asana. This will relax the whole body and mind by slackening voluntary efforts. In other words any tension in the muscles, joints, ligaments or tendons is to be avoided.

Another tradition requires to resort to what is called **pranadharana**. This is done by attending to the incoming and outgoing flow of breath and to feel its touch at the tip of the nose. Such awareness of breathing also helps one to relax properly during the final position of asana. We shall study the physiological mechanism of pranadharana later on.

So, the effortlessness, easiness or absence of tensions and particular awareness are the characteristics of asana.

ततो द्वन्द्वानभिघातः ।

Tato Dvandvanabhighatah

(P. Y. S. II : 48)

Actually speaking this is the result of the practice of asanas. When the above mentioned principles are followed during the practice there is no clash between two opposites. On the contrary they work in co-ordination with each other. These two opposites may be two types of neural impulses like facilitatory and inhibitory impulses or sympathetic and parasympathetic activities. The neuromuscular activity is smoothly executed e. g. contraction of the biceps and the relaxation of the triceps of the arm occurring at the same time helps smooth bending and stretching of the elbow joint. These opposite functions are spread over in every system of the body and a smooth harmonious working of the body and mind depends upon a judicious reciprocity in two opposite functions. So if the asanas are done in a proper way as said above, there would be no clash between such internal mechanisms.

Aims and objectives of Asanas

Asanas are placed in the beginning of the yogic curriculum i.e. first in Hatha yoga and third in Ashtang Yoga by Patanjali. The purpose is evident. Asanas are physical practices to prepare body and mind for the further steps in Yoga like Pranayama, Pratyahar, Dharana etc. The body and mind are made healthy and are trained in such a way that a necessary equilibrium (समत्वं, Samatvam) is established in overall functions. It is a sort of reconditioning of psychophysiological mechanisms of the body as a whole. One reaches the stage of Asanajaya (आसनजय) i. e. mastering the asanas which is expected to come after a good deal

of practice of asanas. Now one is able to sit hours together in a meditative asana without any discomfort or internal disturbances.

Basically asanas are expected to counteract anga-mejayatva (अंगमेजयत्व) i. e. instability due to the disturbances (विक्षेप vikshepa) in the tonic rhythm of the body. This tonic imbalance in muscle is removed with the practice of asanas as they tackle the root causes of the tonic imbalance e. g. tremor, emotional conflicts, stresses, tensions etc. Asanas thus mould our body and mind, make them stable and perfect to bear the spiritual forces in further steps of yoga.

According to Hatha yoga also the asanas contribute to stability, health and suppleness which are necessary to advance in yoga (कुर्यात् तदासनम्, स्थैर्यम् आरोग्यं चांगलाघवम् । Kuryat tadasanam sthairyam arogyam changalaghavam) Asanas overcome fickleness or instability in various functions of the body (आसनेन रजोहन्ति Asanena rajohanti).

In nutshell, we can say that asanas re-establish a harmonious functioning of the whole body and brings about an integration of nervous system. This is important so as to overcome the internal and external disturbances on the path of yoga.

MECHANISM OF ASANAS

We know that the central nervous system

(CNS) uses its lower centres of integration for the maintenance of posture and equilibrium. These lower centres are situated in the medulla, pons, cerebellum, mid brain and basal ganglia. Various reflexes are integrated by these lower centres, below the level of consciousness to maintain the posture. Postural reflexes take place involuntarily due to the stimulations of different sensory proprioceptors and visceroreceptors in muscles, joints, tendons, sole of the foot etc. A tonic rhythm could be regulated by the lower centres quite independently and efficiently when the higher centres in the cortex do not interfere with them.

Any voluntary effort on the part of body or mind signifies an activity of the higher centres which dominates the lower centres of integration. This disturbs the normal activity of the lower centres for the postural reflexes. The motor impulses are directly passed on to the skeletal muscles. In this, one may exceed his own limits to bend or to stretch which would cause many more further disturbances to him.

We know that atleast in the beginning when one learns any asana for the first time or when he practises it for first few days to get acquainted with it, a little exertion is caused to the muscles, joints, tendons etc. Slowly he or she increases the time for the maintenance of different asanas. In this phase the volition plays a dominant role over the lower centres. One remains engaged in the muscle stretchings, contractions, pulls and pressures or the compressions of the abdomen and a slight discomfort here and there. But we would talk about anatomico-physiological mechanisms which are involved particularly when one gets established in

the practice of asanas and can now practise them quite easily without any exertion. Of course even from the beginning one can learn and develop a habit of doing asanas in a very slow and smooth manner and avoid any exertion. Unfortunately many individuals, as they consider asanas as exercises, practise them either in the form of isometric or isotonic exercises, and continue this practice for ever.

Naturally the results will be different according to the way of performance. We would consider first the isometric and isotonic elements as and when brought about in the practice of asanas and then discuss their performance according to the tradition.

In order to achieve the final stage in asana one puts his voluntary efforts. The muscles and joints are actively stretched and are maintained as such for sometime in the final stage. Such sustained contraction of the muscles against resistance is nothing but the isometric exercise. **Active stretching** - pulling of the muscles results in an active contraction as a result of stretch reflex mechanism (page 30). Tension is increased which is felt in the joints, tendons and muscles. If it is severe, it gives rise to pain and one becomes uncomfortable. This brings in fatigue and exhaustion or even tremors in the body. Such isometric activity puts extra load on the circulation and the respiration as the demand of energy and oxygen from muscles increases. Experimentally it was observed in the case of paschimottan that when it is practised with such isometric element, increases the heart rate by more than 30% over the initial resting heart rate. One remains disturbed by the sensation of tension, pain and discomfort in the body. He

cannot concentrate his mind anywhere and gets irritated and despaired. Due to these disturbances, one is compelled to release the asana in a very short time.

Such performance acts mainly on superficial muscles than on the deep muscles and their nerves. Internal pressure changes and proprioceptive mechanisms hardly get any time to influence the nervous system. One cannot experience the special pattern of posture as the sensations are dominated by heavy muscular tensions. The active element in the practice will stimulate the sympathetic activity which would give rise to some other unwanted mechanisms in the body and develop more psycho - physiological tensions. Now imagine, what would happen if the individual continues such practice for months together. Irritability, tension, inflated ego-consciousness, offensive and impulsive nature etc. are the probable symptoms in such individuals practising the asanas in this way.

However, for the hypotonic conditions of the individual, slightly active stretchings and sustained contractions will develop necessary tone and strength in various muscles. The individual would feel active, fresh and enthusiastic due to sympathetic action.

Experimentally, it has been observed that inspite of an excellence in the posture the degree of contraction of muscles (EMG activity) was increased due to such isometric element brought into the practice and the duration of maintenance was decreased. This indicates a heavy strain, developed unnecessarily in the musculature which may reflect upon the cardiovascular system.

Some times asanas are also practised as freehand (isotonic) exercises where each asana is repeated for three or four times rapidly even with jerky movements. Here the movements are more prominent, leaving no time for the maintenance of the posture. The yogic value of such Isotonic (dynamic) practise is very much doubtful even though they may improve stamina and endurance of the body. They cause more heat and sweat production, and give rise to sympathetic activity. They strain the cardiovascular system, consume lot of energy and consequently exhaust the body. For hypotonic conditions of the muscles however, this sort of exercise is useful along with a slight increase in the muscular efforts.

Now let us consider what happens when asana is practised with proper relaxation in the muscles or with reduced voluntary efforts and without any tension in the joints, muscles and tendons. The attention is focussed on the infinite or simply on the breathing process (Pranadharana). This attitude of an observer (as a third person) where the awareness is directed towards the breath, further relaxes the body and slackens the voluntary efforts. Mind remains engaged in such a thing from where no thoughts are possible to come. In the absence of mental thought processes and voluntary efforts, there is no cortical activity for the period of maintenance of asana. The lower brain centres of posture and equilibrium are now free to work efficiently. The type of postural reflexes and their stimulations, however, depend upon the particular pattern of posture adopted.

It will be seen that most of the asanas resemble the postures which are natural postures for the lower animals like crocodile, cobra, fish, peacock etc. which are maintained by their lower brain centres involuntarily. It seems therefore that the patterns of asanas have been purposely designed to give maximum scope to the lower centres of integration. Also, in the absence of cortical influence there is no activity on the emotional or intellectual level and therefore there is no tension to disturb the individual atleast for a few seconds.

In such type of effortless, easy and comfortable maintenance of the posture, various muscles-tendons and joints are stretched smoothly and pleasantly. This static stretching with relaxation is known as **passive stretching** where the stretching of the muscles and tendons do not cross the natural limits and therefore there is no strong reflex contraction of the muscles. On the contrary muscle may surrender easily to such passive stretching, offering no resistance. There is no question of muscular tension on the other hand the muscle tone remains at its optimum level or even gets reduced to a great extent depending upon which muscles are involved in which pattern of posture. We have seen that the muscle tone is the basis of posture and gets influenced by emotional or psychological state of an individual. When the muscle tone is reduced due to the passive stretching of the joints and muscles, it has got a soothing or tranquillising effect on the nerves. The emotions cannot remain elevated. They are calmed down. Thus one tackles his own emotional 'make up', reduces the emotional tensions and becomes more and more relaxed. There is an absence of the internal disturbances

(Vikshepas) or clashes (Dvandvas) and hence one can overcome an instability (angamejayatva) in the body and mind. Internal awareness in such relaxed and stable posture not only tranquilises the mind but also condition it through the postural reflex-cerebellum-hypothalamus functional axis. The sympathetic activity is withdrawn and the parasympathetic activity restores the stability on various levels. Now the body starts telling the mind through various sensations which are perceived from proprioceptors and are integrated by the lower centres, involuntarily. That is why a long term effect of such performance is seen on the behavioural pattern of the individual.

Electromyographic (EMG) studies have also shown that the effortlessness and the relaxation brought by the above method could reduce the muscular activity or tension in the muscles even in case of paschimottan and ardhmatsyendrasana. The duration of maintenance was also increased by 10 to 50% and the Heart rate did not increase more than 6%. This indicates that energy cost of these asanas was reduced to a great extent. Therefore there is no question of exhaustion or strain on the cardiorespiratory systems. Individual could spend more time to maintain the asanas, which is important to get maximum benefits from the adopted postural pattern. The passive stretching of muscles and ligaments gets more time to percolate deeply upto the periosteum (covering of the bone) and capsules and stimulates the circulation around them. This mild exercise thus maintains their normal healthy condition by making them more flexible.

The visceral organs are made of smooth muscles

which are also influenced by the emotional state of the individual. When the skeletal muscles of the limbs are relaxed, asanas mainly work on the trunk area and the smooth muscles of the visceral organs. The mild pressure changes in the internal organs get enough time to stimulate the autonomic nervous system, particularly the parasympathetic branch of it, which maintains the muscle tone of these organs at the optimum level. Thus the emotional activity (of hypothalamus) of the individual is tackled also through this mechanism.

It will be clear by now that the hypertonic conditions of the individual, could be easily tackled with such performance which would reduce the rigidity of the various joints. The relaxation thus started at the muscle-joint level is important to release the tensions at the higher level.

We know the limit of stretching or contraction of our muscles beyond which it would give rise to the sensation of pain. Such pain is often experienced at the joints and tendons which disturbs us and draws our attention towards it. This indicates a strain and unwanted tension in the muscles and tendons. No doubt, we should assume the posture as near to the final pattern as possible, but also in as comfortable and relaxed way as possible, i. e. with least efforts as possible, just as we do in normal sitting, standing or lying down in a relaxed way and forget about it. In such a relaxed state of joints and muscles, in the final posture there would be a sensation of **pleasant pain** which is the upper limit of our passive stretching. Now in such performance the muscles do not offer resistance but surrender pleasantly

to this relaxed and a limited stretching and one day we reach the complete postural pattern of asana.

CLASSIFICATION OF ASANAS

Looking to their anatomico-physiological mechanisms and effects, asanas could be classified as follows.

1. Cultural or corrective asanas : These are to be practised to train and condition the body and mind to bring about stability, peace and a sense of well being in them which is necessary for pranayama, dhyan etc. The individual is thus directly or indirectly corrected or cultured at some level, where ever necessary, to prepare the basis of higher yoga practices. Following sub-divisions of this group will reveal their working pattern in this direction.

Sub group (A) This group of asanas predominantly work on and through :

- i) Visceral organs and the sensory inputs from them, arising due to the pressure changes brought about in the intra-abdominal cavity, e. g. Yoga mudra, Paschimottan, Mayurasana, Ardha-Matsyendrasana, Supta Vajrasana, Halasana, Pawan-muktasana etc.
- ii) Muscles and nerves of the vertebral column as well as the joints and ligaments of the same, e. g. Bhujangasana, Shalabhasana, Dhanurasana, Ardha-matsyendrasana, Chakrasana, Vakrasana, Ushtrasana etc.

Sub group (B) These asanas predominantly work on and through various proprioceptive mechanisms of the skeletal muscles of the body e.g. Baddha-padma-sana, Gomukhasana, Matsyasana, Vajrasana, Trikonasana, Bhadrasana, Padahasthasana, Supta-vajrasana etc.

Sub group (C) These asanas predominantly work on and through the vestibular organ for the sense of body balance. e.g. Shirshasana, Sarvangasana, Viparaitkarni, Garudasana, Vrishchikasana, Vrikshasana etc.

2. Relaxative Asanas : These are meant for the relaxation of body and mind which helps the corrective posture and their mechanism. They remove the physical and mental tensions and work at the level of consciousness. These asanas even assist meditative asanas and pranayamas, dhyana etc. e. g. Shavasana and Makarasana.

3. Meditative Asanas : These asanas provide a comfortable and stable sitting position of body for a steady mind for meditation, dhyana etc. e.g. Padmasana, Siddhasana, Swastikasana, Samasana.

Now let us consider the salient features of these groups and their possible mechanisms in the body.

CULTURAL ASANAS

Important objectives of cultural asanas could be summarised as follows :

1. To produce physiological balance in different systems of the body for their harmonious working. This will provide the best organic vigour to the individual.
2. To train the nervous system, specially the autonomic nervous system in such a way that it could easily bear the interaction of spiritual force (Kundalini) when aroused.
3. To bring in stability and peace of mind as well as a sense of well being. To condition various joints, their muscles and tendons to offer a stable and comfortable posture for higher practices like pranayama, dharana, dhyana, etc.

Salient Features

- (1) The movements to acquire and then to release any asana, are very smooth and slow. That is why the reciprocal activity in the muscles and joints can have full play and gets maximum time to correct the tone in the muscles and to influence circulation around them. These slow movements and the maintenance of asana in the relaxed way, requires minimum muscular activity and energy and therefore they do not put any burden on the systems. Thus heart rate, respiration rate remain in the normal range. This indicates no strain on the cardiorespiratory mechanism.
- (2) In asanas like Paschimottana, Halasana, Chakrasana, relaxation in the final posture allows gravity to act as a stretching force and the muscles are passively stretched. In asanas like Vakrasana, Ardha-matsyendr-

asana, matsyasana, the locks and holds help the muscles to remain in stretched condition, while in Bhujangasana, Shalabhasana, Dhanurasana etc., an effort to maintain the posture stretches the muscles. Such passive stretching brings down the muscle tensions and thereby correct the tone in reciprocal group of muscles.

(3) Cultural asanas provide best possible movements for the spinal column. (i) **Forward bending (Flexion)** - Paschimottana, Halasana, Yoga Mudra (ii) **Backward bending (extension)** - Bhujangasana, Dhanurasana, Ushtrasana, Matsyasana, Naukasana (iii) **Lateral bending** - on right and left sides - Chakrasana (as developed by swami Kuvalayananda), Konasana (iv) **Rotation of the spine in vertical axis** - Vakrasana (swami kuvalayana-nda), Matsyendrasana (v) **Topsy-Turvy and balancing** against gravity - Sarvangasana, Shirshasana, Viparitkarni, Mayurasana, Kukkutasana, Bakasana.

(4) Even the trunk movements are also slow and hence there is a gradual movement of the vertebrae. The deep muscles and the ligaments of the vertebral column are stretched in different degrees and in different directions. This exercise keeps the spine flexible and elastic or supple and prevents rigidity of its muscles and joints. In growing children (above 12 years of age) these asanas can influence the growth and development of the individual vertebra by stretching or producing traction in them. These asanas give full scope for free natural movements of all the joints of the body including those of vertebral column. The blood circulation around the joints increases. The nutrition of the joints is improved and the waste products are efficiently removed.

This prevents the stiffening of the joints and increases their mobility. In sarvangasana, for example, due to the chin-lock position of the head, the arteries of the cervical spine are stretched. It presses the soft tissues, jugular veins and thyroid gland and causes temporary redistribution of the flow of blood from the brain. When the pressure is removed, the reactive increase in the blood supply probably causes the effective mixing of thyroid hormones with the circulation.

(5) One thing which could obviously be noted in the corrective asanas is that exercise of the trunk portion is more emphasised. The action of the particular posture in the asana is centred on the vertebral column, visceral organs and the nerve roots in this region. The circulation is increased and the nerves are toned up as they get fresh nourishment. This strengthening of the nerves in the viscera including spinal cord and sympathetic cords is necessary to enable the practitioner to withstand powerful action of kundalini. It has been seen experimentally that the balanced functioning of sympathetic and parasympathetic nervous system is brought about by the yogic curriculum consisting of maximum number of corrective asanas.

(6) The increased visceral circulation and the alternate pressure changes brought about in the viscera promotes and preserves the health of the endocrine glands in the abdominal and pelvic region and thus provides a proper background for the nervous activity. Due to the pressure on the abdominal walls the visceral organs are massaged and thus are toned up. As already mentioned before, during the maintenance of different asanas the

abdominal cavity undergoes pressure changes which are reflected on the visceral organs like bladder, colon, stomach, lungs etc. Even different breathing phases (inhalation-exhalation) continued purposely in any asana have been seen to give rise to either positive, negative or fluctuating type of pressure changes. These pressures along with the stretching of the visceral muscles stimulate the vegetative nervous system through visceroreceptors and if the cerebral cortex is not engaged in any of these activities, it brings about the emotional stability in the individual while maintaining the optimum visceral tone.

(7) We have seen that the mental characteristics or even the personality is associated with the postural condition e. g. disappointment or depression results in a total or in part flexion of the body while exciting and stimulating situation causes extension of the body. That is, any attitude of the body is related with the emotional or psychological factors which contribute to the personality. Typical postural patterns of cultural asanas when practised judiciously, would definitely remove minor functional and structural defects in these factors to render balanced and undisturbed personality.

We know that the postural activities depend on the muscle tone of the skeletal muscles, which is maintained at the optimum level due to normal stretch reflex mechanism through cerebellum. If the corrective asanas are practised in effortless manner the cortical activity (intellect) does not interfere with Cerebellum-hypothalamus functional axis and that is why new emotional tensions cannot play their vicious role in the body. On the contrary due to the passive-stretch reflex mechanism

the muscle tone is reduced to the optimum level which reduces the existing emotional tension. The individual experiences peaceful and pleasant mind. Thus a long practice is expected to bring about the behavioural changes or corrections involuntarily, due to the changes in tonic background. It even changes one's total outlook towards his life.

(8) In topsy-turvy postures, due to upside down position of the body, the cardiovascular reflex mechanisms are stimulated. Now the venous return becomes very easy as it is not working against gravity. The problem of varicose veins would not arise if one practises these postures daily. Brain gets easy supply of blood thus refreshing the nervous tissues. In order to prevent the blood flow under great force towards the brain, the new pattern of reflex mechanism is set for the circulation in the upper extremity. This not only checks the forceful circulation in the brain during the posture but also keeps the blood pressure at the optimum level during other day-to-day activities of the body.

(9) These topsy-turvy as well as the balancing asanas stimulate vestibular organs of balance and improve their function. Balancing against the gravity requires your constant attention as well as a steady mind. Regular training in these asanas make the mind more and more stable and better concentrated as the external tensions or the internal thought processes cannot continue when you are aware of the function of balance.

Thus cultural asanas condition various muscles, joints, tendons and many reflex mechanisms to make the body and mind suitable for higher yogic practices.

RELAXATIVE ASANAS

The aim of relaxation in Yoga is directly related to the awareness and aims at the release of tensions working at the level of consciousness (Chitta चित्त). The concept of Chitta - Vishranti (चित्तविश्रान्ति), i.e. the tranquility in the consciousness, is emphasised in Hatha-Yoga which realised the value of a relaxed mind. They knew that mental tensions can give rise to physical (muscular) tensions. These mental tensions are the results of the external stresses and tensions or the conscious internal thought processes which in turn work on the muscles and the nerves of the body, making them more tensed. Tensed muscles obstruct the blood flow and easily get exhausted. Tensed nerves influence almost all the systems and disintegrate the harmony amongst them, as tensed nervous system cannot coordinate their functions properly.

Shavasana and Makarasana are two asanas from Hatha Yogic school to provide best relaxation in supine and prone positions of the body respectively. They provide both physical as well as mental relaxation at the level of consciousness, if properly and sincerely practised. It should be borne in mind that this is not only a 'resting condition' of the body or mind, or 'sleeping' but a conscious relaxation. It is also not the idle or lazy state of mind. On the contrary the relaxation of mind and chitta makes the individual more fresh and energetic against the tiring routine of work and different types of tensions and stresses of life. Regular practice of

shavasana keeps our mind more balanced and away from the mental fatigue.

Salient Features

- (1) Shavasana provides the most natural (anatomical) position of the body which contributes to the physical and mental rest at the first instance. No imbalance is left in the muscles of the limbs etc.
- (2) Horizontal position of the body on ground helps in easy blood circulation. No system of body is required to work against the gravity e. g. Flexors and extensors can also relax as there is no question of balancing the body against the gravity. Metabolic rate comes down. Even the blood pressure and heart rate are reduced to minimum because there is no need of force to circulate the blood. Breathing becomes slower, slightly-deeper, rhythmic and mostly abdominal in nature as one progresses in relaxation.
- (3) We are not conscious of this abdominal type of breathing when we simply take rest, but in shavasana the movements of the abdomen are consciously attended at least in the beginning which initiate the relaxation at the nervous level. The abdomen moves up when we inhale and again sinks down when we exhale. If one does not find these movements happening, he has to correct his breathing as said above in order to relax thoracic musculature. In makarasana the movements of lowermost lumbar and upper hip portion along with the breathing are attended.

- (4) Abdominal breathing has a soothing effect on the nervous system. It helps to tone up the abdominal organs and removes their congestion if any. It has a beneficial influence over the circulation in the pelvic and abdominal area. Diaphragm also moves slowly.
- (5) Even before attending the breathing in this way all muscles are relaxed consciously one by one or simultaneously. We can experience (with the closed eyes) the difference between the tension and relaxation in the muscles of the joints, limbs etc. This sort of training is required atleast in the begining to relieve muscular tensions as well as to engage the mind properly which otherwise undergoes a conscious thought process and brings more tensions through memory, intellect and imagination.
- (6) One can easily practise pranadharana, in which he observes his own breathing and its flow passively. The current of air which moves in, upto the lungs during inhalation and goes out through nostrils again during exhalation is witnessed (as a third person). This breathing awareness also relaxes the body more as one forgets about rest of the body.
- (7) Various stages in the technique of shavasana have been developed upon the principle of from gross to a subtler level, as the relaxation at the level of chitta is not so easy to reach. One is gradually trained to withdraw his awareness from the gross aspects of the body and to develop awareness of more and more subtler functions of the body and mind. For example, after the

stages, mentioned above one develops the awareness of touch of air inside the nostrils. Even a minute difference of temperature of inhaled and exhaled air is felt at the tip of the nose which takes the individual to deeper and deeper relaxation.

(8) One realises the reduction in the number of thoughts entering in the mind when he practises any stage mentioned above. He can easily develop an attitude of a witness (साक्षीवृत्ति) towards his own thoughts. He does not get involved in any thought processes but just observes them coming and going out of body-mind complex. One forgets rest of the body. This resolves tensions and thus greatly helps in mental relaxation. Thus one gets more and more training for contemplating mind to the infinity as the awareness is withdrawn from all sensory and motor organs and focussed on the thoughts as an observer. One experiences a 'thoughtless' condition of the mind where all analytical activities of the intellect are absent. There would be no function of interpretation. This helps individual during the practice of other asanas to allow the mind to be focussed on the infinity and to slacken the efforts (motor function). If Chitta (consciousness) is thus going to be relaxed in shavasna, then its contact with sensory and motor organs will progressively become weaker and ultimately it could be completely cut off. It gives a momentary experience of Samadhi (समाधि) to the practisant. Such functional dissociation of chitta from organs is termed as Pratyahar (प्रत्याहार). So Shavashna also helps a practitioner for a stage of pratyahar and other higher yogic practices.

(9) Even though, sedatives and tranquilisers apparently give a feeling of relaxation, it is temporary. The chemical action of these drugs is to inhibit or to block the neural mechanisms at some level or the other in the nervous system. The mental tensions and the disturbed mind remain as they are and again start working in the same fashion soon after the effect of the drug is over. One gets addicted of these drugs. Same thing is true to some extent in hypnotically induced relaxation. In yogic relaxation the whole approach seems to allow the tensions to come to the surface in an inactivated condition so that they can find their way out without disturbing the individual. The tranquility and peace of mind coming to the person after such type of relaxation is of a lasting nature.

MEDITATIVE ASANAS

An uninterrupted process of meditation requires minimum or no disturbances from the external and internal environments. That is, only in the absence of sensory inputs from the receptors, the person will be able to concentrate his mind and to meditate. Padmasana, Siddhasana, Samasana, Swastikasana, are important asanas for meditation. The aim of these asanas is to provide a firm and comfortable posture for the practice of Pranayama, Dhyan, etc. for hours without any disturbance. Cultural and relaxative asanas prepare us for such stability and tranquility of mind which is required for meditation.

Salient features

(1) Meditative asanas provide broad triangular base for the body, formed by two knees and the pelvis. This broad base gives firm foundation to the body, and makes it steady and stable. Even if one loses the body sense during meditation, he remains balanced due to sub-conscious control over it.

(2) The spine is kept in vertical and straight position i. e. no new curves are introduced in the backbone. This is important for higher spiritual practice. Straight spine avoids compression of the abdominal organs and keeps the abdominal muscles free for breathing activity. It facilitates easy movements of the diaphragm in breathing. Digestive organs can carry out their function smoothly including peristaltic movements. straight spine prevents the practicant from going to sleep. The position of the hands serve as the support for the spine like a bracket.

‘समंकायशिरोग्रीव’

(Samam kaya shiro grīva)

This phrase in Bhagwad Geeta says that the head, neck and rest of the body should be well balanced. Some times people translate it as ‘erect spine’ due to some wrong understanding. An erect spine may disturb its natural curvatures and also, in order to maintain it some conscious efforts are required. On the contrary balanced condition of the body, neck and the head helps proprioceptors of the flexors and extensors of the spine to maintain this equilibrium involuntarily.

(3) In such condition, the breathing movements continuously change the diameter of thorax. The centre of gravity shifts forward and backward although the thorax oscillates minutely. This stimulates the proprioceptors of the trunk muscles in the front and in the back and bring about their contraction and relaxation alternately through stretch reflexes. The lower brain centres can, thus easily maintain the balance of the body and keep up inner awareness in the practicant who cannot fall asleep while meditating.

(4) When other activities are reduced, the nerve roots of the trunk, particularly the pelvic region, are free to convey special sensory impulses from coccygeal, sacral and lumbar regions towards the central nervous system. these impulses are mainly due to the stimulations of visceroreceptors and proprioceptors in these regions. One can easily become aware of these sensations in this calm and quiet condition.

(5) Experimentally it has been observed that the energy requirement in such asana is the lowest of all sitting postures. This indicates minimum production of CO_2 due to a negligible amount of muscular activity. This brings down the activity of the lungs and the heart to a minimum.

(6) Locking of the legs at knee joints which are not only flexed but rotated outwardly, minimises the blood circulation and prevents accumulation of blood in them. Horizontal position of the lower extremities helps the venous return. There is no need to return the blood

against the force of gravity. Extra blood is now diverted to the pelvic and abdominal region. The nerves in this region get richer blood supply and are thus refreshed and toned up. It may be remembered that the sacral region possesses parasympathetic net work.

(7) The particular angle of femur bones of the thighs and the pelvic girdles facilitates the formation of mula-bandha and uddiyana bandha.

Thus the meditative asanas provide a steady and comfortable but, wakeful 'seat' with least burdens of the body and make the mind free for meditation. Padmasana is also found to be the basis of few cultural asanas e. g. Baddhapadmasana, Yoga mudra, Matsyasana, Parvatasana etc.

ASANAS AND EXERCISES

Many people consider asanas as exercises and practise them on exercise pattern. Keeping their therapeutical view aside, if asanas are to be practised to maintain normal health of body and mind, or to advance on the path of yoga, then they differ from exercises in many respects. Let us see these differences one by one.

1. As the aim and objectives of asanas and exercises are different, the mode of their performance is altogether different. The movements are slow, steady and smooth to attain and to release any asana. The phase of maintenance of asana is more important than

movements. Slow movements require the action of deeper muscles also.

Exercises are performed in a fast or speedily manner leading to an exertion and fatigue. All the movements are gone through with a jumpy and jerky element. The maintenance phase is rarely observed which is too, for a very short period.

2. The effect of asanas is more on the trunk part. Proprioceptive and viscerceptive mechanisms are given free scope. The special patterns of asanas when maintained, produce pressure changes in the internal cavities of the visceral organs which influence the circulation in the abdominal part. Nerve roots in the abdominal region are toned up.

Movements of the extremities are more prominent and also important while exercise to the trunk is secondary in exercises. It acts mainly on superficial skeletal muscles and their nerves. The circulation is increased in the periphery. The movements in exercises are quick or rapid and may be of repetitive nature.

3. In asanas, movements of the spinal column are done in all most all directions and with their possible range of movemets. The vertebrae are not compressed in only one direction but are stretched in all the four directions and in a rotation. There is a counter movement for every movement of the spine in asanas. The deep muscles of the spine and its ligaments are brought into action.

In exercises, only a particular movement is repeated to develop strength and skill of some part of the body. Any one side is developed (asymmetrically) or conditioned in many exercises.

4. There is no purpose of muscle building in asanas. Heavy muscular activity is avoided in asanas and hence the energy requirement is also less than that of exercises. Asanas do not put any burden on cardio-respiratory mechanisms on the contrary the tensions are reduced at various levels.

Heavy muscle masses are built through exercises for more and more muscular strength. These bumpy muscles are cultivated for a manly look and are regarded as the sign of physical fitness and vigour. But really speaking they do not improve stamina or physical endurance. After a particular age these over developed muscles act mainly as parasites, sapping their energy and nutrition from other tissues. They become loose and give an ugly shape to the body. Heavy muscular exercises increase the work of cardiovascular system putting undue strain on it.

5. Skeletal muscles are passively stretched and hence the muscle tone can not increase beyond a particular level. The muscular tensions are on the other hand reduced to a minimum thus there is no strain on the muscles and nerves. The passive stretching percolates upto the capsule and deep ligaments of the joints, which stimulates blood circulation around them and ensures their health.

In exercises, there are heavy and sustained contractions (isometric) and active stretchings of muscles against some graded resistance. These voluntary efforts increase the tension in muscles and give rise to painful sensations. When the exercises are finished, one feels tired and a need to take rest. After the session of asanas is over, on the contrary, one feels fresh, relaxed, and energetic with the sense of well being.

6. As the voluntary efforts are withdrawn in the final stage of asanas the activity of the motor cortex is gradually reduced or even withdrawn completely. Now a proper inner awareness is automatically developed where one can observe (as a third person) or experience various sensory inputs coming from proprioceptors and visceroreceptors. The lower brain centres are given free scope to integrate these impulses to maintain a proper equilibrium.

In an attempt to achieve the goal in exercises, one makes lot of voluntary efforts. The activity of the motor cortex dominates all the lower centres and even exceeds limitations of the body. One remains aware of the external things (external awareness) since the reaction is to be measured outside the body with the judgement of exteroceptors e. g. bull-worker exercise.

Thus we find that basically the technique and the mechanism of action in asanas and exercises are quite different. The motivational part is also different and therefore they should never be confused for each other.

It is clear that the health and hygien of the internal organs is maintained by asanas on the physical level. The sensory inputs which are initiated in the trunk region, due to the special pattern maintained for some length of time, bring about the nerve culture. A proper tone in the neuro-muscular system is established. A feeling of exhilaration freshness, lightness as well as the stability and balance of mind are common benefits of asanas even to the physical culturist.

One should, however, take into account one's own limitations due to age, sex and the bodily (hypertonic or hypotonic) conditions, rigidity or flexibility of the joints etc., while practising asanas. One should avoid pulling or pressing of the body parts and undue strain on them in order to emulate the perfect pattern of the asana, which may otherwise cause a sprain, a tear of fibrous tissue or an injury to the joints. Asanas should never be resorted to in a competitive spirit and no violent efforts, to reach the final posture, are to be made. 'Pleasant pain' is the limit of normal range of movement as has been described above which would lead one progressively towards the final posture of asana, one day.

PRĀNĀYĀMA

Pranayama occupies second place in Hatha-Yoga while it constitutes fourth part of ashtanga Yoga. A serious students of yoga is expected to pass on to Pranayama when he becomes well-versed in asanas. A stage of asanjaya (आसनजय) is achieved, by which one can sit for hours together, steadily and comfortably.

The word Pranayama is formed by two words i. e. 'Prana' and 'Ayama'. Prana means a subtle life force which not only provides energy to different organs (including mind) but also control many vital life processes (e. g. circulation, respiration etc.) of a living being. Ayama signifies the voluntary effort to control and direct this Prana. Breathing is one of the manifestations of the activity of Prana on a gross level. This is the only system available to us which could be exercised voluntarily. Secondly, this system (pranic activity) is linked with the nervous function (mental activity) on one hand and the consciousness (चित्त) on the other. Yoga has taken best advantage of this situation, considering that the mind could be controlled effectively with the voluntary control over breathing which in its turn would control materialistic inclinations of chitta.

Therefore, pranayama essentially becomes a process by which the subtle prana is controlled, by regulating the breathing, voluntarily. For our understanding, Prana is simply 'a breath' and Ayama means a control over it. Just like we have 'speed breakers' on the road to control the flow of traffic, we bring a 'pause' in the breathing. So pranayama means a voluntary and temporary pause in the movement of breath.

तस्मिन्सति श्वासप्रश्वासयोर्गतिविच्छेदः प्राणायामः ।

(P. Y. S. II 49)

Tasminsati svasaprasvasayorgati vicchedah Pranayamah.

The meaning is that the pause, brought in the movement of inhalation and exhalation, is nothing but pranayama.

Patanjali has explained four types of pranayama on the basis of the nature of the pause. 1) Pause after prolonged exhalation. 2) Pause after deep inhalation. In these two types one has to make special voluntary effort to hold his breath. In third and fourth variety such special efforts are not required. 3) An effort-less pause brought any time one wants to bring for a considerable time. 4) A pause is maintained without any physical effort as in third variety but it is after many inhalations and exhalations are gone through.

In yogic literature the first type of pranayama is called **Bahya Kumbhaka**, second type **Abhyantara kumbhaka**, while third and fourth types are called **Kevala Kumbhakas**.

Svatmaram Suri, the author of Hathapradipika, mentions eight varieties of pranayama, not on the basis of nature of kumbhaka but on the nature of inhalations and exhalations between which these kumbhakas occur. The technique of all the eight kumbhaka is same. But the technique of inhalations and exhalations is different for each type.

CHARACTERISTICS OF PRANAYAMA

Pranayama is essentially a volitional control of breathing and probably due to this fact, it is referred to as 'Breathing exercise' by many people. But various breathing exercises have been developed on the basis of their oxygen value. In pranayama, on the contrary, the stress seems to be given on the development of kumbhaka i. e. the phase of temporary suspension of breath. Kumbhaka when prolonged maximum, accumulates Carbon-di-oxide in the lungs and when the availability of oxygen is calculated per unit of time the total quantity of oxygen is even less than that of normal breathing for same unit of time. Therefore it is wrong to say that the pranayama provides more oxygen to the body. Secondly when we sit for pranayama the relaxed sitting condition of body would require very minimum quantity of oxygen. Our body cannot and does not store oxygen anywhere or accepts it unless it is required. On this basis, one can understand that pranayama has no oxygen value particularly when the phase of kumbhaka is also practised.

Pranayama is practised consciously i. e. one remains fully aware of different phases of it. In other words

pranayama is never done mechanically. Awareness of breathing is most important in the practice of pranayama. Therefore, pranayama could not be considered simply as breathing exercise.

Talking, singing are also voluntarily controlled respiratory acts but they are not to be regarded as pranayama. Singing or talking involve some kind of emotions or expressions and the communication, while pranayama does not express any emotion, thought or desires. Simply breath holding in underwater swimming is also not a kumbhaka, as the physical and mental standstillness (absence of mind-intellect function) is also expected along with the kumbhaka,

Each cycle of pranayama is essentially a complex voluntary act, consisting of three distinct phases i. e. Puraka, Kumbhaka and Rechaka. Kumbhakas are naturally of three types.

- (1) Abhyantara or purna or Antarkumbhaka i. e. controlled suspension of breath after puraka. This is the retention of inspired air in the lungs which is compressed in alveoli. Intra-pulmonic pressure is raised.
- (2) Bahya or Sunya Kumbhaka i. e. controlled retention of breath after rechaka phase. The Intra-pulmonic pressure is lowered.
- (3) Keval kumbhaka i. e. suspension of breath some where in a mid-stage, which appears itself automatically after a long practice of pranayama. The intra-pulmonic pressure is kept equal to that of atmosphere.

Prolongation of particular phase for a considerable time is important in Pranayama. Tradition advocates definite proportion of time to each of these three phases of Pranayama.

Hatha yoga also recommends some bandhas to be practised along with each cycle of pranayama. Mula-bandha, Jalandhara bandha and Uddiyan bandha are three important bandhas, applied during Puraka, kumbhaka and Rechaka phases respectively.

Thus the technique of pranayama includes specific rules regarding the method of breathing, the force of breathing, the duration of each phase of breathing, attention or concentration on certain points regarding the process of breathing. We shall deal with some of these characteristics while studying the mechanism of pranayama.

Following principles are important in almost all types of pranayama which are observed commonly during the practice.

(1) One has to sit in any suitable meditative asana, keeping the spine in a straight and well balanced condition. Eyes are closed moderately so that atleast one major external stimulation is cut off.

(2) Inhalation in puraka and exhalation in rechaka is slow, smooth and without any haste. The flow of air is kept uniform, having same force all through out.

(3) Every puraka and rechaka must end quietly. The habit of expanding the chest or contracting the body musculature violently at the end of puraka and rechaka respectively, is avoided consciously. Thus an attempt of snatching and forcing out some more air at the end of puraka and rechaka respectively would only disturb the next cycle of pranayama and nothing else. Therefore puraka and rechaka should end pleasantly, without any strain.

(4) Rechaka is always given longer time than Puraka. The orthodox proportion between Puraka and Rechaka is 1:2. Rechaka should not be prolonged too much otherwise it would hurry up the next puraka. Best way is to allot half the time to puraka than the time for which the rechaka phase can easily be prolonged.

(5) Orthodox practice of pranayama suggests minimum ten rounds at a time. Traditional text like Hatha-Pradipika however, recommends 80 rounds at a time and such four sittings in a day i. e. in morning, afternoon, evening and at midnight.

(6) Jalandhara bandha is applied during kumbhaka. Abdomen is kept little contracted inwardly and maintained in this condition through out the practice.

(7) Increase in the air-way resistance is another peculiarity of Pranayama. Inhaling or exhaling through only right or left nostril (Anuloma-Viloma) or partial closure of glottis to produce sound (in Ujjayi) will constrict air passage. Thus the ratio between volume of air and blood reaching the lungs is changed. Volume of air (ventilation) is restricted.

Aims and objectives of Pranayama

Any activity which requires a total concentration of our mind will also control our breath which may be stopped for a while e. g. while threading the needle, our breathing is stopped for a few moments. This shows clearly that there is a co-relation between our mind and pranic activity like breathing. In an example given above, we experience that the thought processes are also stopped for a couple of seconds as the mind is engaged and concentrated on the thread. That means if we try to control our breathing voluntarily, we would be able to control our mind. Pranayama aims primarily at the control on the mind. When mind is standstill, no thought process or emotional activity is possible. Thus by controlling the mind we would be able to control different emotions and when emotions are under control, the temperament and the moods, desires and natural instincts of mind are also controlled automatically.

चले वाते चलं चित्तं निश्चले निश्चलं भवेत् ।

योगी स्थाणुत्वमाप्नोती ततो वायुं निरोधयेत् ॥ (H. P. II 2)

So long as breathing is continued and the air is moving in and out of the body, the mind remains unsteady. When the breath is stopped the activity of the mind is also stopped, and it becomes standstill. Thus a yogi attains a complete motionless state of consciousness. One should therefore restrain one's breath. By pranayama mind is trained and made capable of the process of Dharana (धारणासुच योग्यता मनसः) i e. concentration

of mind on one object or one-pointedness (एकाग्रता) of mind, which is the pre-requisite of dharana, is possible after a long practice of pranayama.

Different Nadis are also purified (नाडीशुद्धि) with the practice of pranayama. Nadis in yoga are the channels or the passages for the transmission of blood or lymph, air or nerve impulse. Most important Nadi which opens after a long practice of pranayama is Susumna. Thus pranayama eradicates all types of mala (मल) or toxins from the body and mind. Mala in yoga is that factor which gives rise to an imbalance in the body and mind by obstructing the normal functions of nadis.

Experimentally it has been established that the attention, mental effort, different emotions and behavioural pattern, bring about some modification in breathing. Now when we regulate our breathing and make it rhythmic, it is possible to make our mind more balanced and to change the behavioural pattern. We can observe this in a serious practitioner of yoga since the natural tendencies and urges arising in his mind are checked.

Thus pranayama can also tackle one's ego-consciousness which is the seed of the instincts, desires and behaviour. When ego is controlled the behaviour of a person also changes. Tranquillity, equilibrium, mental poise result after a long practice of pranayama which lead us to further stages like Pratyahar, Dharana, Dhyana etc. Pranayama also removes the covering on the knowledge and helps for realisation.

(ततः क्षीयते प्रकाशावरणम्)

Hatha-yoga claims to cure all sorts of diseases when pranayama is practised properly. It also warns that if it is not practised judiciously then many diseases may arise (like asthma, constant hiccup, pain in head, ear and eyes etc.). By judicious practice of pranayama one attains sound internal health, steady and peaceful mind, slim and lustrous body.

DIFFERENT TIME RATIOS

In order to maintain uniformity in all the rounds or cycles of pranayama and to allow one to practise within his limitations, different time proportions (ratios) are in vogue today. Such uniform proportion provides a proper (time) relation amongst puraka, kumbhaka and rechaka as far as their duration is concerned. The purpose behind this seems to be to provide one with some means to measure one's own capacity so that one may not transgress and over steps one's own limitations and wreck the delicate and vital mechanism of respiration. Probably this is an answer to commonly arising questions in mind as to how much and how long one should inhale, how long one should retain the breath and how long one should prolong exhalation.

Most favoured view is to have the proportion of 1 : 4 : 2 for Puraka, kumbhaka and Rechaka respectively. Another tradition advocates the ratio of 1 : 2 : 2. Thus if Puraka is taking 5 seconds, kumbhaka should be of 20 seconds and Rechaka prolonged for 10 seconds according to the first proportion. In the second proportion, Puraka is given half the time than that of kumbhaka and Rechaka. This second proportion is found rather easy and comfortable to be adjusted and hence one is

advised to start with this second proportion of 1 : 2 : 2. While introducing the time proportion, however, one should see that he is able to perform Rechaka without any discomfort or restlessness. These time ratios are not rigid rules but serve as guidelines for conscious but rhythmic and proportionate control over the breathing mechanism. Any jerk, strain, snoring, violence or undue sense of suffocation should be avoided completely throughout the practice of pranayama.

Another tradition (Goraksha Samhita) suggests a proportion of 6 : 8 : 5 : for safe and convenient practice of pranayama. All these time proportions are developed or brought into the practice gradually from 1 : 1 : 2 then 1 : 2 : 2 and so on. A feeling of distress or air hunger at any stage indicates some strain somewhere in the practice. Then one has to reduce the proportion of inspiration in puraka so that other phases are also reduced in their duration to avoid air hunger.

All these proportions can easily be brought into practice through mental counts, matras or even with the help of a watch. Thus the phase of kumbhaka is gradually introduced just as a small pause between puraka and rechaka and then the duration of it is increased slowly, so that the balance wheel of respiration is not unbalanced.

MECHANISM OF PRANAYAMA

We know that the respiratory system works involuntarily, depending upon various reflex mechanisms in

the body. The depth and the rate is maintained automatically according to the oxygen requirements of the body from moment to moment. Now, when we bring so many changes in the breathing, voluntarily, the whole mechanism is changed. Let us see what happens when we bring volitional control over breathing during different phases of pranayama.

PURAKA PHASE

Puraka (पुरक) is the voluntary prolongation of the inspiratory phase. Svas (स्वास) is normal-uncontrolled and involuntary-process of inspiration, which is regulated by the respiratory centre in the medulla oblongata. Depth and number of svasas per minute depend on the body requirement of oxygen. Inhalation in puraka is done in a very smooth way by keeping the force or speed of filling the lungs constant and uniform. The force of inspiration is automatically decreased when we prolong the duration of it. In Bhastrika pranayama however, one breathes in and out very rapidly, giving just half a second for one cycle (120 cycles/minute) of puraka and rechaka of the first part of Bhastrika. In some variety of pranayama, puraka is done through only right or left nostril at a time e. g. Lom-Viloma, Surya-bhedan pranayama. In some type of pranayamas the ventilation is reduced by contracting glottis or throat muscles. e. g. Ujjayi, Bhramari etc. Thus the mechanics of inspiration is changed or controlled in terms of time, force, ventilation and depth by volition.

During the phase of puraka the lungs are expanded and the alveolar walls are stretched. After a

particular degree of stretching, the stretch receptors situated in the alveolar walls get stimulated. At this stage, in normal breathing, they would have sent inhibitory impulses to the inspiratory centre and the phase of exhalation would have been started in a reflex. But due to our strong voluntary control in order to continue the phase of inhalation, the poor normal stretch reflex cannot bring about the contraction of the lungs as usual. The stretch receptors are thus trained to withstand more and more stretching without bringing a reflex contraction. This helps us to hold the breath for a long time, easily.

Next factor is the pressure in the lungs. As we continue to inhale, the intra-pulmonic pressure is also raised. The diaphragm does not move freely as in the case of abdominal breathing because the abdomen is kept controlled and slightly inward. Therefore the alveoli in the upper pulmonary part are filled with air and are thus made to participate in gaseous exchange. One uses his inspiratory or the vital capacity of the lungs for prolonged phase of puraka. This has a beneficial effect on the respiration and it then functions more efficiently throughout the day.

During the puraka phase which is a conscious act, the attention is drawn towards the filling of the lungs with air as per ones limit. To keep necessary proportion between Puraka, Kumbhaka and Rechaka, one has to adjust the duration of Puraka so that the Kumbhaka and then Rechaka are gone through smoothly without any sense of suffocation, or pressure in the chest. Thus puraka is not just a mechanical prolongation of inspiration but one has to be completely aware of it.

KUMBHAKA PHASEA

Kumbhaka (कुम्भक) is a voluntarily controlled suspension of breath. Here we would consider only antar-kumbhaka. After a particular stage in puraka, one stops inhalation and retains the inspired air in the lungs for some length of time. The intrapulmonic pressure which is raised to one's optimum capacity, is maintained during kumbhaka. The air is compressed in the alveoli which are stretched to their optimum level. The stretch receptors, however, cannot bring about the reflex contraction of the lungs, as normally they do, due to our strong volitional force.

The ideal duration of kumbhaka is such which would enable one to give double time to rechaka than that of puraka phase. The duration is gradually increased over a long practice of pranayama so that the respiratory centre is gradually acclimatized and trained to withstand higher and higher CO_2 tensions.

Due to the metabolic processes, continuously taking place in the body, CO_2 is produced and handed over to the blood. In normal respiration it is readily thrown out of the body. But now when we retain the breath, the concentration of CO_2 in the lungs and in the blood is increased. If we consider a retention of breath for 20 seconds during which the blood is circulated for more than 25 times, the picture would be clear. The blood-air volume ratio is changed and the gaseous exchange can take place more efficiently.

Experiments have shown that the volume percentage of oxygen absorption or CO_2 elimination increases due to increased duration of one cycle of pranayama but if we divide this increased volume percentage of these gases by the total time of Pranayama cycle, it is found that there is less oxygen absorption and CO_2 elimination per unit of time. In other words, if same unit of time is given to both, the normal respiration and to one cycle of pranayama, the O_2 absorption and CO_2 elimination would be more in normal respiration.

The increasing concentration of CO_2 in blood stimulates chemo receptors adjacent to the walls of blood vessels and the respiratory centre is excited, but it is helpless against the strong volitional control from the cortex. However, First desire or the inner urge (प्रथम उद्घात) arises after some stage in antar kumbhaka which is generally neglected or discarded. There is a second impulse (द्वितीय उद्घात), which is forcing us to exhale, may also be ignored though it is stronger than the first one. A third and a very strong desire (तृतीय उद्घात) arises internally, which usually one cannot and should not neglect. Now rechaka should be started.

During the phase of kumbhaka one is fully aware of the 'fullness' of the lungs and the pressure of the inspired air in the lungs. One may experience a standstillness in the mind or even thoughtless condition of it. To avoid any functional damage to the delicate respiratory system and to produce a typical awareness, tradition advocates Jalandhara Bandha particularly when the duration of kumbhaka is increased.

Role of Jalandhar bandha in kumbhaka

Bandha means a tie. A specific neuro-muscular action around the front neck region in Jalandhara bandha will influence the circulation, nervous function and the glandular (thyroid) secretion. In Jalandhara bandha one bends his head and presses the chin on the jugular notch, firmly. The internal and external carotid arteries, carotid sinus and sinus nerve are pressed due to this sharp bend of neck. It is claimed that when these three (carotid bodies) are pressed, they slow down the heart, reduce the blood pressure and induce a particular (trance like) state of awareness which helps in the mental abstraction from the external things. It helps for inward projection of mind and produces a typical consciousness of the fullness of the lungs or of the increased intra-pulmonic pressure. Thoracic vertebral column is pulled up in the jalandhara bandha and thus one also becomes aware of the stretching in the upper back portion. Jalandhar bandha also adds to the intrathoracic pressure from the upper side.

The blood flow towards the head is restricted. This reduces the possibility of strong stimulation of the chemoreceptors adjacent to the carotid arteries due to increasing CO_2 concentration in the blood. If we do not apply Jalandhar bandha, the respiratory centre is strongly stimulated and even if we build up a strong volitional control against it, other centres like cardiac and temperature regulating centres etc. are influenced. Heart rate and blood pressure goes up; there may be a sweating and giddiness also. If such practice (without jalandhar bandha) is continued daily, the person may

become a permanent victim or susceptible to high blood pressure or palpitation. Jalandhar Bandha, as it prevents extra blood supply to the head, brings about a soothing effect on the nervous system.

Jalandhar bandha also does not allow the deeply inhaled air to rush out with force. If Jalandhar bandha (like a band) is not applied, the compressed air would rush out, as if burst open, through eustachian or auditory tubes to the internal ear and would damage it.

Thus Jalandhar bandha helps us structurally and functionally, to hold the breath easily and to retain deeply-inspired air under pressure. It minimises the inner urges which force us to start exhalation in kumbhaka.

RECHAKA PHASE

After retaining the breath for sufficient length of time in a comfortable manner, the Jalandhar bandha is released and rechaka (रेचक) is started. Again, rechaka is a controlled voluntary exhalation against prasvas (प्रश्वास). Prasvas is a normal exhalation. Only in Kapalabhati we have to breathe out forcefully and rapidly. These quick exhalations help to wash out complete foul air from the lungs efficiently. The control, as in puraka, is brought in terms of time, force, ventilation and flow of the air.

In order to increase the duration of rechaka, the exhalatory force is reduced and limited air is allowed to go out. For this purpose, the exhalation is done only through the right or left nostril (as in Ujjayi, Suryabhedan etc) or the glottis is contracted. By this, one can

regulate the volume of air to be expelled out per unit of time. Thus the air escapes very slowly.

The intra-pulmonic pressure is reduced slowly and due to deflation the receptors are stimulated. At the end of normal exhalation, these receptors send the inhibitory impulses to the exhalatory centre and bring about the inspiration by their reflex mechanism. But now this is not possible for them against our strong volition.

Another reflex which is tackled in rechaka is the chemo-reflex. Up to this stage CO_2 concentration has been greatly increased in the blood. This tries to inhibit exhalation and to start inhalation by stimulating chemoreceptors. But this reflex is also controlled by our volition and we continue to breathe out. The purpose is to acclimatize these receptors to higher CO_2 tensions in the blood. The duration of rechaka is, however, so adjusted that there is no feeling of 'air hunger' at any stage. If it is not well adjusted, the next inhalation is hurried and the whole proportion of the cycle is disturbed.

In rechaka one uses his expiratory reserve volume and then starts next puraka. This helps to get rid off maximum foul air and to breathe in almost a fresh air in the next puraka.

Significance of double proportion of rechaka

One is supposed to adjust the proportion of puraka so as to maintain 1 : 2 time ratio between puraka and rechaka. Even if the duration of kumbhaka is kept

four times more than puraka (in 1 : 4 : 2 time ratio) the rechaka is still given double duration than the puraka. Really speaking the puraka is made short in order to keep double duration for rechaka. This is possible after knowing one's capacity to prolong the phase of exhalation. For example, if one is able to breathe out for 10 seconds comfortably, he should adjust his puraka for only 5 seconds. The reasons for such a proportion may be studied on the psychophysiological basis as follows.

- 1) An instinct of inhalation is always stronger than that of exhalation. This is due to increase in CO_2 tension in the blood at the end of normal exhalation. When we lengthen the phase of exhalation, we mainly tackle this chemo-reflex and discard the urge of inspiration. Prolonged duration of rechaka offers more scope for such training of the chemo-receptors which are thus acclimatized to withstand more and more quantities of CO_2 . This will facilitate an arrest of respiration in the mid stage (Keval kumbhaka) as the baro reflexes are automatically controlled when chemo-receptors are trained.
- 2) It is a common experience of all, that the various tensions are released when we exhale deeply. Prolonged rechaka would naturally liberate more psycho-physiological tensions and we would feel calm and quiet. Intrapulmonic pressure which was developed slowly in puraka and maintained for maximum time in kumbhaka would now also be released in a slow manner giving gradual training to the nervous system.
- 3) A total concentration is required when a particular

time proportion is to be observed in each cycle of pranayama. In prolonging the rechaka, we remain aware of the force and flow of air etc. thus keeping the mind away from the thought processes for maximum time.

4) By increasing the duration of rechaka the exhalation is most complete. The foul air is completely squeezed out from the lungs (except the dead space volume and residual air volume) using the expiratory reserve volume. When we inhale for next puraka of another cycle of pranayama, we receive almost a fresh air from the atmosphere, in the lungs. If the rechaka phase is not sufficiently prolonged, some amount of air remains in the alveoli at the end of incomplete exhalation. This foul air is mixed with incoming new (fresh) air. As the quantity of oxygen is reduced for every cycle, after sometime we may feel suffocated.

5) We build up intra-abdominal pressure during rechaka which is maintained for longer time. Due to this pressure, blood circulation in the lower abdominal region is reduced and now diverted towards the sacral region. When the abdomen is retracted, the lower most portion of the spine (sacrum) is also pulled up. Thus by prolonging the duration of rechaka the sacral nerve roots (including parasympathetic branches) are provided with more nourishment and are also stimulated mechanically for a sufficient time.

In short, during each cycle of pranayama, we tackle all the respiratory reflexes due to our voluntary control over breathing. The cerebro-spinal impulses and the autonomic nerve impulses are integrated. Breathing and

the mental activity are related with each other. Unnecessary thought processes are checked as the mind is engaged in breathing. Mind is more balanced and well controlled. Thus it is prepared for higher stages like Dharana, Dhyana. where one-pointed concentration is required.

DEEP BREATHING AND PRANAYAMA

Pranayama is mostly confused with deep breathing exercises due to some wrong impressions. But fundamentally, both of them differ from each other.

1) Pranayama is a voluntarily controlled breathing which aims at tackling higher brain centres and autonomic nervous system (to bring the mind under control), Deep breathing is aimed at providing more oxygen and to get rid of accumulated CO_2 from the blood. Thus deep breathing is secondary and resorted to overcome a fatigue. Pranayama is never done after muscular exercise. Deep breathing may be voluntary or involuntary (after heavy exercise).

2) Three distinct phases i. e. Puraka, Kumbhaka and Rechaka constitute one cycle of pranayama. The phase of rechaka is always prolonged than puraka. In deep breathing there are only deep inhalations and deep exhalations. There is no question of retention of breath. Phases of inhalation and exhalations in deep breathing are almost equal. A particular time ratio (for proportion) is followed in pranayama while in deep breathing no such proportion is observed. Hence the number of cycles per minute in pranayama may be one or two but in deep breathing it may be 12 to 15 per minute.

3) At least ten rounds of pranayama, two or three times a day, are usually prescribed for normal practice. Hatha-pradipika for example, recommends eighty rounds, four times a day. There is no restriction of cycles in deep breathing. No particular time or posture is required for it.

4) The air way resistance of varying degree is created in different pranayamas during each puraka and rechaka e. g. breathing through only one nostril or contracting the glottis as in ujjayi etc. so that the volume of air reaching the lungs is restricted whereas the volume of blood coming to the lungs remains almost constant. This influences the respiratory efficiency which helps one throughout the day. In deep breathing we can use both, mouth as well as nose for breathing, in which the volume of air is certainly increased over the flow of blood, thus providing larger quantities of oxygen to be readily absorbed in the blood.

5) The lower abdominal and pelvic muscles are kept in slightly contracted condition throughout the pranayama so as to avoid any congestion of the abdominal organs in the pelvic region. It also keeps the diaphragm slightly at a higher level so that one does not exceed his capacities during inhalation. He then uses the upper part of the lungs more. Elevated condition of diaphragm also helps to develop sufficient intra-pulmonary pressure which could easily be felt by the practitioner. In deep breathing the position of diaphragm or abdomen etc. is not important as the purpose is only to provide maximum amount of oxygen to the body.

6) Certain bandhas (Jalandhar, Uddiyan, Moola bandha) i. e. neuro-muscular locks and certain gazes e. g. Nasagra drishti, Bhramadhya drishti (नासाग्र दृष्टि, भ्रू-मध्य दृष्टि) are to be employed during different phases of pranayama. The eyes are closed to reduce the sensory inputs from external environment. No such neuromuscular control or a gaze is observed in deep breathing.

7) In order to maintain the proportion amongst purakā, kumbhaka and rechaka phases and also to control the force of breathing or to produce a particular sound from the throat (Ujjayi, Bhramari) even if kumbhaka is not practised, one has to be completely aware of his breathing mechanism. Thus the mind remains engaged in the breathing process. In advanced stages one has to receive special sensations along the spinal cord etc. Deep breathing is done mechanically, without proper concentration. The thought processes may continue during deep breathing.

8) Increased concentrations of CO_2 in pranayama stimulate various psycho-neuro-endocrinal mechanisms. Due to rhythmic and daily practice of pranayama the sub-cortical centres are more integrated and cultured. Deep breathing provides large quantities of oxygen to the respiratory system thus activating the individual for more physical work.

Thus the mechanics of breathing, the immediate and long term effects, techniques of breathing and the purpose of pranayama and deep breathing are quite different and therefore pranayama should never be considered as deep breathing exercise.

ANULOMA - VILOMA

This pranayama is also known as Lom-Vilom (लोम-विलोम), Nadi shodhan (नाडी शोधन) or Nadi-shuddhi (नाडी शुद्धी) pranayama. The main characteristic feature of this pranayama is the alternate breathing through left and right nostril with or without kumbhaka.

Most of us may not be aware of the fact that we breathe through only one nostril at a time and even the force of breathing is also not equal for both the nostrils. Experimentally it has been observed that the right and the left nostril do not work evenly and equally. Either of them remains blocked while the other works freely. Both the nostrils rarely function simultaneously. If one finds them open, it may be for a short period when one nostril is slowly getting blocked and the other one is being opened i.e. during change of nostril. Swara Yoga (स्वर योग), the science of breath claims that there is a natural rhythmic change in the dominance of one nostril to that of the other occurring every 2 to 3 hours. It also believes that a particular type of nostril dominance is preferable for a certain activity in day-to-day life.

Yoga not only recognised this uni-nostril dominance from the beginning but also has asserted certain psychological changes and behavioural tendencies correlated with three conditions i.e. Right or left nostril dominance and equal functioning of the two nostrils at a time. Modern sciences have revealed several chronic functional disorders ranging from simple intellectual asthenia to visceral disfunction like asthma, peptic ulcer,

dysmenorrhoea etc. associated with permanent single nostril dominance on account of the septum deviation or some other obstruction in the nostril.

Unfortunately the science of physiology has not considered this fact much except some ventilatory studies on uni-nostril breathing. Physiologically, our body tries to adjust itself to the environmental temperature changes through alternate vaso-dilatation and vaso-constriction mechanism. It is more marked at the extreme terminals like tips of fingers, toes, ear-lobes etc. Nose is also a terminal point where this phenomenon occurs. The nostril opens up when the blood capillaries of the mucous membrane constrict. Nostril will be blocked if the capillaries dilate.

Yoga believes that left nostril breathing dissipates more heat from the body or in other words it has a cooling and relaxing effect on the body. Left nostril is known as Ida nadi (इडा नाडी) or Chandra (चंद्र moon) nadi which cools the body. Ida nadi represents the constructive, anabolic, energy-conserving aspect of the pranic (autonomic) function. The right nostril is known as Pingala nadi (पिंगला नाडी) or Surya nadi (सूर्य नाडी). It has got heating and activating effect on the body. It represents destructive, catabolic, and energy-consuming aspect.

The alternate functioning of the left and right nostril in proper rhythmic manner is therefore essential for a good health. Yoga insists upon this balanced and simultaneous functioning of the two nostrils to create a bala-

nced condition of the mind for the meditation. Gherand
 samhita advocates that one should perform the alternate
 nostril breathing before the main pranayamic technique,
 as it cleanses the impurities from various nadis. Hath-
 apradipika gives a detailed technique of this pranayama
 to remove different malas from the body (sharir mala
 (शरीरमल) and mind (chitta malas चित्तमल), which
 otherwise disturb their functions by obstructing the flow
 of pran through nadis. When both the nadis work evenly
 and simultaneously the third nadi starts functioning.
 This nadi is known as susumna nadi (सुषुम्ना नाडी).
 Prana is supposed to travel through this nadi during
 pranayama. In order to keep the two nostrils open for
 pranayama, yoga prescribes the use of Yoga-danda
 (crutch like instrument). It has been proved experim-
 tally that if the yoga danda is placed under an armpit
 and one leans over it to give proper pressure in that
 region, the force of breathing increases in the nostril
 opposite to the yoga danda and decreases in the nostril
 of the same side. Thus we can open the blocked nostril
 within a few seconds by placing yoga danda under
 the armpit on the opposite side and pressing it a little.
 If we maintain this pressure for a long time it may
 decrease the flow of the nostril on the same side and
 finally block it. Similarly if one lies comfortably on the
 left side, the whole weight being borne by the lateral
 side of the left thigh, temporal region, shoulder and arm,
 one will find that after some time the right nostril is
 functioning fully well while the left nostril is getting
 blocked.



Fig. Arrangement of the right hand fingers for Lom Vilom.

Now let us see the technique and the mechanism of Lom-Vilom pranayama in brief. One sits in padmasana or in any suitable meditative asana comfortably. The spine is kept in a straight position and the abdomen is maintained in a controlled state all throughout. After this one forms a special mudra of the right palm by folding and supporting the index and middle finger together at the bottom of the thumb as shown in the figure. The ring and the small finger are free for closing the left nostril. The right nostril is closed with the help of the thumb.

RIGHT NOSTRIL

LEFT NOSTRIL

- | | | | | |
|-------------|----|----------|----|-------------|
| (2) Rechaka | ←— | Kumbhaka | ←— | (1) Puraka |
| (3) Puraka | —→ | Kumbhaka | —→ | (4) Rechaka |

One inhales slowly and deeply through the left nostril. The flow of breath is kept uniform till the inhalation is complete. This is puraka phase. The left nostril is immediately closed by ring and little finger. So now both the nostrils are closed. Jalandhara bandha is also applied to retain the breath according to one's capacity (यथाशक्ति). This is kumbhaka phase. With a strong desire to release the breath, one releases the right nostril by removing the thumb from it and starts exhaling very slowly and deeply through this right nostril. Progressive contraction of the abdominal muscles is also allowed without any strain so that the exhalation is complete. This is rechaka phase. Now the next puraka is done through the same (right) nostril. After doing kumbhaka as before, the rechaka is done through the left nostril. This is measured as one round of nadishudhi pranayama in which puraka phase is long and slow (दीर्घ and मन्द) and the phase of rechaka is still longer and slow (प्रदीर्घ and मन्द) in nature. Such 3, 7, or 10 or even more rounds are gone through at a stretch. The proportion of puraka, kumbhaka and rechaka may be 1:2:2 or 1:4:2. In this pranayama the breathing is very smooth and without any frictional sound.

The beginners should, however, practise only puraka and rechaka phases through left and right nostrils alternately without kumbhaka. Even this much control slowly trains the nervous system associated with the breathing mechanism. Kumbhaka phase should be introduced in the form of a pause to be extended gradually over a long practice.

Since the breathing is done through one nostril at a time during puraka and rechaka, the minute ventilation is reduced. The amount of air reaching the lungs is restricted while the volume of blood remains unchanged, that is, the ratio between air and blood volume in the lungs is changed. The gaseous exchange therefore takes place more efficiently.

The alternate breathing through the two nostrils brings about a harmony in the two opposite functions in the body. It balances the mind. The awareness is directed towards the breathing process which helps to create tranquility and peace in mind. It also makes the mind stable. This pranayama has a soothing and purifying effect on the nervous system. The autonomic nervous system is related with the breathing on one hand and with the emotional behaviour of the individual on the other. Various emotional tensions are thus reduced and one feels relaxed and light. This is experienced even after a short practice of this pranayama. A proper inner awareness is developed which is required for the higher yogic practices or to receive peculiar sensory inputs from interoceptors in the thoracic and the pelvic regions. This pranayama also improves the function of digestion and sleep.

UJJAYI PRANAYAMA

Ujjayi (उज्जयी) pranayama is one of the eight types of pranayamas, described by Svatmaram, the author of Hathapradipika. The chief characteristic of this pranayama is the audible sound produced due to the partial closure of the glottis, during puraka as well as rechaka. This simple variety of pranayama can be practised in sitting or standing condition or even while walking. Of course one should not practise kumbhaka when ujjayi is to be performed in standing or walking.

Padmasana or any other suitable meditative asana is adopted and palms are pressed upon the knees. This automatically makes the spine straight, avoiding any extra antero-posterior curvatures in the vertebral column. It also prevents bulging of the abdomen and helps one to control the abdominal muscle easily. Eyes are closed moderately. The mode of breathing in Ujjayi is slow and smooth.

Puraka Phase

Every puraka, including the first, starts after complete exhalation. The breath is drawn in through both the nostrils. The abdominal wall is slightly contracted and is held in this retracted condition throughout the practice of pranayama. This controlled abdomen is beneficial in many respects than the protracted or relaxed abdomen as follows.

1. The diaphragm is pushed up due to the constant abdominal pressure and is held in this elevated

condition all throughout. The descent of diaphragm is not possible now. The breathing thus essentially becomes thoracic in nature, having prominent action of the intercostal and clavicular musculature. Hence the upper portion of the hands and slightly elevated condition of the shoulders help further in this respect. Intra-pulmonic pressure falls more which allows more quantity of air and consequently larger amount of oxygen to be sucked in the lungs than when the abdomen is protruded out. It also helps one to have a complete exhalation in rechaka.

2. X-ray studies have revealed that the lowermost (sacral) part of the spine is pulled up. At the same time the intra abdominal pressure is raised due to inward contraction of the abdomen. The peripheral nerve plexuses and the spinal nerve roots are thus stimulated along with the visceroreceptors which generate peculiar sensory impulses in this region.

3. It has been also observed experimentally that the duration of kumbhaka is slightly increased when the abdomen is kept controlled than when it is protracted or relaxed.

4. Since the maintenance of the abdominal muscles in contracted condition requires proper conscious control, it helps the practitioner atleast in the beginning to divert his attention from external things and to focus it inwardly. Mind is thus not allowed to wander.

मुखं संयम्य नाडीभ्यामाकृष्य पवनं शनैः ।

यथा लगति कण्ठातु हृदयावधि सस्वनम् । (H. P : II : 51)

Just like one sips a cold-drink through a straw, the air is sucked (आकृष्य) slowly through both the nostrils. For this, a sufficient negative pressure is created in the lungs and the throat is contracted partly. However, in order to prevent the friction of the air in the upper nasal region, one is advised to feel the touch of the air in throat which indicates the friction of air in throat. By this, the possibility of damage in the olfactory region, which is responsible most of the time for dryness and pain in the upper nares and some nervous disorders, is removed. Relaxation of the facial muscles also help greatly in this regard.

The partial closure of the glottis reduces the air passage in diameter thus increasing the air-way resistance. When the air flows over this reduced air passage, it produces a sound like sibilant 'sa' due to friction of the air. In order to produce the sound in a low but sweet and uniform pitch, the air is allowed to flow slowly and smoothly. The force of inhalation is automatically controlled. Thus the minute ventilation is reduced. Obviously, a proper awareness is required for producing the sound in a uniform pitch and thus the mind remains engaged in the breathing process. Sensation of filling and emptying of the lungs can easily be felt.

The proportion of puraka phase constitutes the measure for fixing the (time) proportion for kumbhaka and rechaka phases also. The feeling of fullness of the

lungs upto the neck is the limit of inhalation in puraka. However, one should fix the proportion of puraka according to his capacity so that same proportion of puraka and other two phases is maintained for all the rounds to come.

Kumbhaka Phase

At the end of puraka the glottis is completely closed and the Jalandhara bandha is employed by bending the neck in front and fixing the chin in the jugular notch. If one requires, both the nostrils are also closed with the help of thumb and the fingers. Now the inspired air cannot escape through the air passage.

The beginners should, however, resort to only puraka and rechaka in the proportion of 1 : 2 along with the distinctive sound. The kumbhaka is introduced in the form of a short pause between puraka and rechaka and by practice it is lengthened gradually. Although the time proportion is followed as per the tradition (1 : 2 : 2 or 1 : 4 : 2), the duration of kumbhaka really depends upon two things (1) No sense of suffocation is experienced at any stage in kumbhaka and 2) the rechaka that follows kumbhaka is very smooth and without any discomfort or strain.

An advanced student of yoga also employs uddiyān bandha and Moola bandha during kumbhaka. Due to Jalandhara bandha the upper back muscles are stretched and the dorsal spinal column is pulled up a little. This adds to the intra-pulmonic and intra-thoracic pre-

ssures. Uddiyan bandha increases intra-abdominal pressure and pushes the diaphragm up. Thus these three pressures are deliberately raised and mentained during kumbhaka. The purpose behind this seems to generate peculiar sensory nerve impulses by stimulating visceroreceptors including chemo-receptors. One peculiar sensation, described in Hathapradipika, is the tingling sensation felt all over the body particularly up to the hair and tips of nails. Perhaps the tolerance of the receptors to the maximum stimulations, is to be increased. One may also experience the standstillness (स्तम्भवृत्ति) in the mind after a long practice of kumbhaka. To terminate kumbhaka the jalandhara bandha is first released and rechaka is started.

Rechaka Phase

Rechaka is to be done (traditionally) through the left nostril but for the convenience and to avoid the complexity and confusion, it may be done through both the nostrils. When the rechaka is to be done through the left nostril, the right nostril is closed with the help of right thumb. The abdominal wall is progressively contracted so that the diaphragm is pushed up for maximum voluntary exhalation. The relaxation of the chest is properly controlled so that the emptying of the lungs is uniform and progressive till the end. Friction of the air in the nasal part is avoided. The glottis is kept partially closed and the frictional sound, approximately similar to that in puraka, is produced in a low but uniform pitch. It is rather easy to contract the throat and to produce frictional sound in rechaka than in puraka. Normally the exhalatory phase is controlled when we talk. The sound is rarely produced during inhalation.

Some times mucous may come in the throat due to the exhalatory force against a narrow air passage which may drag the mucous coming in its way. Sometimes one may also experience dryness in the throat. Therefore the number of rounds should be fixed accordingly. Friction in the throat is attended as in puraka in order to produce uniform sound and also to reduce awareness of the external environment.

The duration of rechaka is always longer than puraka. The orthodox proportion between puraka and rechaka is 1 : 2. That means if the puraka is given 5 seconds the rechaka should be done for 10 seconds. But the rechaka should be done with proper care so that the next puraka is not in any way hurried. In fact the time ratio or the duration of all the three components of pranayama should be such that no undue suffocation is felt at any stage of pranayama, irrespective of the number of rounds one wants to undergo. Usually 10 to 20 rounds are practised at a stretch in one sitting, depending upon the capacity and need of the individual.

It has been observed experimentally that the cardiac output is increased in ujjayi pranayama than even in deep breathing and the normal breathing. It is mainly due to the changes in the intra-thoracic and intra-pulmonary pressures during different phases of this pranayama which are also exerted on the heart and its blood vessels. For example, the intra pulmonic negative pressure during puraka phase for 4—5 seconds increases the venous return to the heart while positive intrathoracic and intrapulmonary pressures during rechaka which are maintained for 10 seconds would increase better emptying of the blood vessels.

As already described under the general mechanism of pranayama, the various interoceptors are stimulated due to increased stretching, pressure and chemical changes during puraka, kumbhaka and rechaka phases. This exercises both the central as well as the autonomic nervous system in order to facilitate keval kumbhaka. The motor nerve impulses flow to the respiratory centre as well as thalamus and hypothalamus parts of the brain. The external stimulations and the thought processes (which have become weak) are not attended but on the contrary the mind is directed towards the sensations aroused due to the above mentioned stimulations. This pranayama has a soothing effect on the nervous system. The mind is calmed down and stabilized. After a good deal of practice of this pranayama the concentration power and the one-pointedness of the mind is increased. The necessary internal awareness is developed. Thus the mind is not only properly controlled but also made suitable and perfect for dharana and dhyān. When the mind is brought under control the other two sides of the consciousness that is the intellect and the ego are also controlled. One feels relaxed and peaceful.

This pranayama has been found useful in improving the voice. It also helps to correct the defective breathing pattern. One feels energetic and balanced especially when there is no kumbhaka in the practice. Hatha-pradipika claims that this pranayama removes throat diseases caused by phlegm and increases the gastric fire. It destroys all the diseases of the dhatus (humours), nadis and a dropsy disease too.

KAPALBHATI

Literally, Kapalbhathi means an exercise that makes the forehead shining. It is one of the six cleansing processes, described by Hathayoga as Shatkriyas. This purificatory process involves the breathing apparatus, nasal passages and the sinuses in the skull and cleanses them effectively. Gherand Samhita mentions three varieties of kapalbhathi. All the varieties have a chief characteristic feature of cleansing the nasal passage in the skull. At present we shall refer to the technique of kapalbhathi as is given in Hathapradipika.

Padmasana is the best asana to practise kapalbhathi. After acquiring padmasana the palms are pressed moderately on the respective knees and the hands are kept straight. By this, the vertebral column automatically becomes straight. The upper part of the chest and shoulders are slightly elevated. Due to this the abdominal muscles remain free and their movements are facilitated and easily controlled during the practice. Padmasana also provides a firm foundation to the practicant due to broad triangular base. The vibrations or the mechanical jerks produced during vigorous practice of kapalbhathi are easily absorbed and counterbalanced by this foundation. The force created by the abdominal muscles is directed towards the chest instead of going down towards the legs as it happens if kapalbhathi is practised in the normal squatting position.

Kapalbhathi is essentially a breathing exercise. Puraka and rechaka are done in a quick succession with the help of the abdominal muscles and a diaphragm.

The thoracic part is more or less unmoved. Therefore it is basically a Diaphragmatic or Abdominal breathing where very little work is left for ribs and their muscles. There is no question of retention of breath in Kapalbhathi. Rechaka is more important part of this practice.

Rechaka

Rechaka consists of an active (voluntary) and quick exhalation. The front abdominal muscles are contracted suddenly and vigorously around and below the navel region. This gives a strong inward push to the abdominal viscera, which in its turn pushes diaphragm upward in the thorax. Diaphragm now exerts an active pressure on the lungs due to which the air is quickly expelled out with force. In kapalbhathi, both the nostrils are wide open and there is no question of closing the glottis. The muscles of the neck and face are kept relaxed so that air escapes smoothly. Although the friction of the air is avoided in the interior nasal passage little friction takes place in the opening part of the nostrils, producing a sound just like it is produced while blowing the nose.

The thoracic part is kept relatively in fixed condition. If the thoracic part is allowed to be expanded with every stroke then the pressure, exerted due to strong abdominal thrust upon the lungs, is dissipated in all the sides. This is mainly because the sides of the diaphragm are lifted and it becomes flat when the chest is expanded. The air will not be blown properly but the muscular work would unnecessarily increase. On the contrary

when the chest is not allowed to move and is maintained in a fixed condition, the pressure is received in the centre of the diaphragm, giving an axial direction to the force of blowing. The strength of air current is increased and the air passage is cleansed more effectively.

During each inward stroke the whole pelvic region is automatically contracted, resulting in the vigorous contraction of the anal sphincters. It is desirable that at least in the beginning one should avoid mool-bandha voluntarily. Later on, after one gets established in this exercise mool-bandha may be introduced in the practice of kapalbhati.

The force of the current of air also exerts a suction pressure on all the cervices of the nasal passage as well as on the opening of the sinuses. This helps to drain out the mucous contents and other secretions from these parts.

Puraka

For the normal breathing, the process of inhalation is active where as the process of exhalation is passive. But in kapalbhati puraka is passive and rechaka is active in nature. At the end of a quick exhalatory stroke, as the exhalation is complete, one just relaxes the abdominal muscles. As soon as the pressure is released, the abdominal part protrudes due to the weight of the visceral organs. At the same time the diaphragm descends easily, increasing the vertical diameter of thorax. The intrapulmonary pressure is lowered due to increased pulmonary capacity and the atmospheric air enters the lungs. Thus puraka in kapalbhati provides air

for the next expulsion in rechaka. Puraka is a bit slow, smooth and quiet while rechaka is sudden, forceful and vigorous in nature. At the end of puraka a strong abdominal push for the next rechaka is given. Thus puraka and rechaka follow each other during which the abdomen moves forward and inward. Blowing sound is also produced. The whole thing appears like a bellow of a blacksmith भस्त्रावल्लोह कारस्य रेचपुरौ ससंभ्रमौ । कपाल भर्तिर्विख्याता कफदोषविशेषणी ॥ (H. P II : 36)

Thus one cycle of kapalbhati consists of only puraka and rechaka. The standard rate at which the cycles are practised rhythmically is 120 cycles per minute. The speed is however acquired slowly by practice. The co-ordination between the abdominal movements and the phases of breathing is essential i. e. The exhalation and inward stroke of the abdomen as well as the relaxation of abdomen and inhalation are to be synchronised properly. Normally 10 or 20 cycles are practised in one round. The number of cycles for one round is gradually increased by daily practice. After mastering the technique the recommended speed is achieved. Such practice for half to one minute is sufficient for all practical purposes. There should be no undue strain on the system at any stage. The force of expulsion, the speed, the number of expulsions in one round, the number of such rounds in one sitting are adjusted according to one's need and capacity.

Now let us observe some of the physiological effects of kapalbhati. The respiration obviously becomes shallow in nature. The tidal volume decreases from

450—500 ml. (in normal breathing) to 175 ml. during kapalbhati. Minute ventilation increases about three times (20.4 Lt/min) more than that in the normal breathing (7.1 Lt/min). Oxygen consumption increases due to increased work of breathing. Consequently Carbon-di-oxide is eliminated in large quantity from the system. Oxygen consumption increases by 10 to 14% over the normal value and then decreases after the practice is over by 3% than the normal value. This practice establishes such a metabolic condition in the body that the respiration is slowed down. In other words a sort of quieting of the respiratory centre is brought about by kapalbhati. Experimentally it has been observed that the duration of antar kumbhaka increases if it is practised immediately after kapalbhati for 30 to 45 seconds. It may be remembered that kapalbhati for 20 to 40 seconds is included in the first part of Bhas-trika pranayama.

Thus Kapalbhati not only cleanses the respiratory tract and keeps it free of impurities, mucous etc. but also affects the nerve centres in navel region and the nerve roots in the skull. It helps in awakening of kunda-lini power, if practised for maximum duration. On physical level it makes the individual fresh within no time. It gives excellent massage to the abdominal visc-are and improves digestion. During Kapalbhati the blood circulation of the periphery and the extremity, is reduced and thus the increased blood circulation in the pelvic region tones up the nerves, and muscles. It also removes excess of fat from this region.

UDDIYANA BANDHA

Uddiyana bandha (उड्डियान बन्ध) is an exercise of diaphragm and the ribs. It is practised either in sitting or standing position. This practice also forms a basis for Nauli Kriya. Different technical terms related to this practice are in vogue. Although the technique and the application of these practices differ, they bear a common characteristic feature of ascending movement of diaphragm. When uddiyana bandha is applied in pranayama, a slight contraction of the abdominal muscles is maintained during Puraka, Kumbhaka and Rechaka phases.

1. Uddiyana Mudra : The abdominal wall is maintained in a slightly retracted condition and the normal breathing is continued with the help of chest.

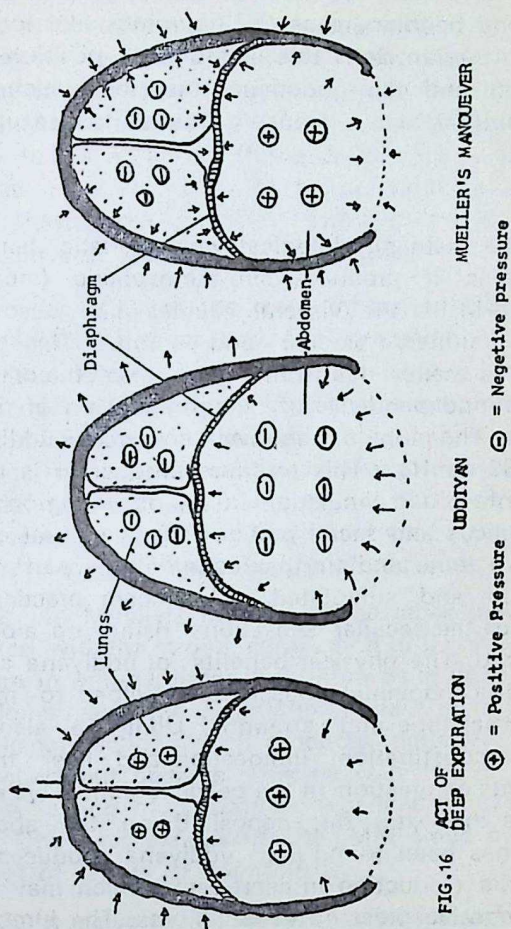
2. Tadagi : In the supine position the knees are folded and kept vertical. Feet are placed near the body. After deepest exhalation uddiyana is practised as usual. The abdomen is sucked in which gives an appearance of tadaga (dry pond) to the abdomen.

3. Tadagi Mudra : In the same supine position the abdomen is drawn little inside and the breathing is continued with the chest.

Now let us see the technique and the mechanism of uddiyana. If uddiyana is to be practised in sitting position, one sits in padmasana and places the palms on the knees. In standing position one bends little forward,

bends the knees a little, and rests one's hands either on the thighs or on the knees. Legs are kept apart. Position of the hands is important as it not only supports but facilitates the action of the thoracic cage and fixes up the neck and the shoulder muscles properly.

Having adopted the right posture for Uddiyana one exhales deeply even by contracting the abdominal muscles. The breath is held out and a strong mock inhalation is attempted i. e. one expands the chest by raising the ribs as if inhalation is being done. Actually the air is not allowed to flow into the lungs. For this one can even close one's nostrills in the beginning. The abdominal muscles are relaxed at the same time. Thus in the mock inhalation the atmospheric air does not enter the lungs but the chest is expanded as it would be in any inhalation. The diaphragm is therefore lifted up and the whole abdomen gets sucked in towards the spine, taking a concave appearance. Bending posture helps in giving greater abdominal concavity. It may be remembered that in normal inhalation the diaphragm moves down when the chest is expanded. In uddiyana it is moving up. The above mentioned condition is to be maintained till one gets a strong desire to breathe in. While releasing, one allows the chest to relax and the abdominal muscles to come to their normal position gradually and inhales as usual. This is one round of uddiyana. The optimum duration of one round is 15 to 30 seconds which helps to produce nauli for a longer duration. Such three to four rounds are practised with or without the normal breathing in between the two rounds. Obviously, uddiyana is practised on an empty stomach and bladder.



It would be clear from the above discussion that anatomically, uddiyana means the rising up of the diaphragm and bandha means the neuromuscular locking at the navel region. It is this anatomical position of the diaphragm and the abdominal muscles which enable some spiritual forces (sensory inputs) to rise up along the spine.

The main physiological characteristic feature of uddiyana is, it produces sub-atmospheric (negative) pressures inside the visceral cavities like oesophagus, stomach, urinary bladder and colon. This vacuum creation is mainly due to the rising up of the diaphragm which is independent of the expansion of the ribs (Fig 16). The range of negative pressure in uddiyana is -20 to -80 mmHg. This vacuum production is thought to promote blood circulation in the pelvic region around the umbilicus and sacral part of the vertebral column. The nerve roots and the plexuses of this part will be toned up and stimulated. A sincere practicant can experience the peculiar sensations rising up along the spinal cord. The physical benefits of uddiyana are also great. The abdominal muscles are helped to maintain their normal tone and strength. Uddiyana also helps to relieve constipation, indigestion and liver troubles. It prevents congestion in the pelvic region. This exercise mobilizes the extra fat, deposited on the abdominal wall. It has been found that uddiyana produces sinus bradycardia (reduction in heart rate) which may be due to the negative pressure in the thorax. The lumbar part of the vertebral column is stretched and the sacral part is pulled up during uddiyana.

It has been found that in an enthusiasm, and due to lack of information, people introduce some other technique instead of uddiyana. This increases the possibility of practising two types of phenomena described in the medical physiology namely Muellers Manoeuvre (MM) and Valsalva Manoeuvre (VM). A yoga teacher is expected at least to know about these techniques in order to see whether his student is practising Uddiyana, MM or VM. All these three practices differ in the technique, mechanism and their effects, as follows.

1. In uddiyana the mock inhalation is attempted by expanding the chest and the relaxation of diaphragm. The abdomen remains in the relaxed condition. Intrathoracic and Intragastric pressures become negative. A suction is felt in the pelvic region and the lower abdomen. There is no question of exertion as one practices uddiyana with minimum efforts. Sensory impulses are expected to rise along the spinal cord. Flying up of the diaphragm is the main feature of uddiyana.

2. In Muellers Manoeuvre the mock inhalation is attempted with the strong contraction of diaphragm. The lungs are in end-expiratory condition as in uddiyana but the abdomen and the diaphragm remain in a state of isometric contraction which produces negative pressure in the chest but positive pressure (Fig 16) in the abdomen. A feeling of suction is experienced in the neck region. One feels exhausted after MM since one has to make lot of efforts to maintain it.

3. In Valsalva Manoeuvre the muscles of the chest and the abdomen undergo a sudden, and strong contraction after a slight deep inhalation, producing a sust-

ained expiratory effort with the closed glottis. This produces a positive pressure in both, the chest and the abdomen. Obviously, this stage is difficult to be prolonged for a longer duration. One would get tired with even one round of this strenuous practice. We often produce such positive pressures during urination and defaecation etc. for a very short period.

Thus it would be clear that the sensory aspect is important in uddiyana. One is expected to receive these sensations rising up along the spinal cord from the lowermost portion of the trunk. Uddiyana should be practised cautiously since it produces negative pressures in the viscera and influences blood circulation as well as the endocrine function.

NAULI KRIYA

Nauli (नौलि) is one of the Shatkriyas mentioned in Hathapradipika. It is an abdominal exercise, meant for cleansing the colon. Its characteristic feature is the isolation and manipulation of the right and the left abdominal recti muscles. Uddiyana is a basic technique for nauli and nauli forms the essential part of the Basti kriya. One who maintains uddiyana easily for 15 to 20 seconds, can perform nauli effectively.

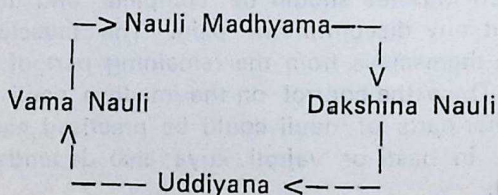
While maintaining uddiyana, a forward and slightly upward thrust is given to the central abdominal portion between the umbilicus and the pubic bone. This contracts the two adominal recti muscles (Fig 10, Page 25) between the pubic bone and the ribs and stand out prominently. These vertical muscles are isolated while the transverse muscles etc. are kept in a relaxed condition. An equal pressure is given on both the knees with the help of palms so that the isolation is complete and two recti muscles stand out side by side in the centre. This is Nauli madhyama or Madhya nauli (मध्य नौलि)

First of all, one should practise and master the technique up to madhya nauli. The isolation of both the recti muscles should be complete and maintained without any discomfort or pain. The muscles should project themselves from the remaining part of the abdomen. Once the control on the madhya nauli is gained the other parts of nauli could be practised easily. The success in basti or vajroli kriya also depends on this control.

While maintaining nauli madhyama one bends little more on the right side and straightens the left side. This helps to relax left side of the abdomen. The pressure on the right thigh or knee is increased and at the same time the pressure on the left knee is released. Thus the right rectus alone is contracted and rolled off to the extreme right side. The left rectus is kept inactive. The isolation and projection of only right rectus is called Dakshin Nauli (दक्षिण नौलि)

Now, bending little more on the left side and simultaneous application of the pressure on the left knee makes the left rectus isolated and rolled off to the extreme left side. The right rectus is relaxed at this time. The relaxation of the right side of the abdomen and straightening of the right side at the same time helps further in this manipulation. This is known as Vama Nauli (वाम नौलि)

When one gets full control over these three aspects of nauli, one can easily roll the recti clockwise or anti-clockwise several times. This is known as Nauli Chalan. The whole sequence of rotation is gone through in a quick succession, without any pain, discomfort or strain at any stage. The whole manipulation is continued till one strongly desires to breathe in.



The main characteristic of nauli is the development of subatmospheric pressure inside the various abdominal organs like stomach, urinary bladder and mainly the colon. This creation of negative pressure was investigated for the first time by swami Kuvalayananda in 1924. He gave the name 'Madhavdas vacuum' after his Guru, to this partial vacuum created in nauli. This investigation discarded the hypothesis of antiperistalsis given by some medical authorities to explain the water suction in the colon during basti. Anti-peristalsis could not explain the water suction in the urinary bladder, nor flushing of the intestinal tract. Further these pressures were also recorded simultaneously in all the internal cavities including oesophagus. The magnitude of pressure during dakshina and vama nauli has been found to be in the range of -20 to -60 mmHg and during madhya nauli from -35 to -80 mmHg. This negative pressure is responsible for suction of water and other viscous liquids in basti and vajroli respectively. It is clear that this development of suction pressure is mainly due to the isolation of the abdominal recti muscles, as well as the little movement of the diaphragm. In X-ray studies it was revealed that the right and left domes of the diaphragm moved independently of each other in daks-hina and vama nauli. Different parts of the colon also move due to rolling manipulation in nauli and thus causes redistribution of the colon contents. The lumbar vertebral column gets stretched.

Thus nauli is an excellent exercise for the abdominal viscera. It maintains the optimum tone of the abdominal muscles. It strengthens them due to which the

abdomen cannot bulge out. Nauli renders the gastrointestinal system healthy. It relieves constipation, indigestion and improves functioning of liver, pancreas etc. It increases the blood circulation in the pelvic region due to high negative pressures and enriches the nerves in this area. Increased circulation removes the waste products more effectively and prevents congestion in the lower abdomen. It removes fat deposition from the abdominal wall. The nerve plexuses and their fine terminals in the pelvic region are stimulated mechanically. The nature of sensation may vary from individual to individual.

Thus nauli is a cleansing process influencing the abdominal organs powerfully and eliminating various malas on the physical level. It also purifies different nadis by removing malas from them. It stimulates the autonomic nervous system and maintains the optimum level of all physiological and endocrine functions in the lower trunk. This helps to maintain the healthy condition of the body. 3-5 rounds of nauli at a stretch are sufficient for the maintenance of normal health.

INDEX

- A— Abdominal recti muscles 24
Acceleratory impulse 37
Active posture 65
Active stretching 76
Adrenal glands 51
Aims and objectives of asanas 73
Aims and objectives of pranayama 107
Anatomy, definition of, 3
Antagonist muscles 22
Anterior lobe 50
Anuloma viloma 123
Asana 67,
Asanas and exercise 96
Autonomic nervous system 44
Awareness 46
- B— Backward bending 85
Bahya Kumbhaka 102
Bones 53
—types of, 53
- C— Calcitonin 51
Cardiac muscle 26
Cell 5
Central nervous system 35
Cerebellum 38
Cerebral cortex 37
Cerebrum 37
Cervical vertebrae 55
Chandra nadi 124
Characterisitcs of asanas 70
Characteristics of pranayama 103
Circulatory system 11
Classification of asanas 82
Colon 10

- Composition of inspired and expired air 20
- Conditioned reflex 44
- Connective tissues 7
- Consciousness 46
- Control of posture 63
- Control of respiration 18
- Corrective asanas 82
- Cranial nerves 40

- D— Dakshin nauli 148
- Deep breathing and pranayama 120
- Diabetes millitus 52
- Diaphragm 23
- Different time ratios 109
- Digestive system 9
- Double proportion of Rechaka 117
- Ductless glands 49
- Dynamic aspect of asanas 70

- E— Efficient posture 62
- Elongated bone 54
- Endocrine system 49
- Epithelial tissue 6
- Excitatory impulse 37
- Excretory system 57
- Exteroceptors 47
- Extremities 4

- F— Fibres - White 22
- Red 22
- Flat bones 54
- Freely movable joint 54
- Forward bending 85

- G— Glands
- endocrine 50,51
- Gonads 52
- Gray matter 36

H— Head 4

- Homeostasis 49,59
- Human body 4
- Hypertonic condition 29
- Hypothalamus 39
- Hypotonic condition 28

I— Ida nadi 124

- Inactive posture 66
- Inborn reflex 44
- Inhibitory impulse 37
- Insulin 52
- Intensity of sensation 49
- Irregular bones 54
- Islets of Langerhans 52
- Isolation of Recti muscles 147
- Isometric contraction 31
- Isotonic contraction 32

J— Jalandhara bandha 127

- Joints, various types of 54

K— Kapalbhathi 136

- Keval Kumbhaka 102, 104, 135
- Kidneys 58
- Kumbhaka phase 11, 102, 104, 132

L— Lateral bending 85

M— Madhavdas vacuum 149

- Madhya nauli 147
- Mechanism of asanas 74
- Mechanism of pranayama 110
- Meditative asanas 93
- salient features of, 94
- Motor nerves 43
- Muellers manoeuvre 145

- Muscles, different types of 21, 26
- Muscle tone 26
- Muscular fatigue 33
- Muscular system 20
- Muscular tissues 7

- N—** Nadi shuddhi 123
- Nature of sensation 49
- Nauli Chalan 148
- Nauli kriya 147
- Nauli madhyama 147
- Nervous system 34
- Nervous tissue 7
- Neuromuscular locking 144

- O—** One pointedness 135
- Organs 8
- Oxygen debt 34

- P—** Parasympathetic nervous system 45
- Parathyroid gland 51
- Passive stretching 79
- Perception 48
- Peripheral nervous system 36
- Pingala nadi 124
- Pituitary gland 50
- Posterior lobe 50
- Postural reflex 63 64
- Posture 61
- classification of 66
- Pranadharana 72
- Pranayama 101
- characteristics of 103
- mechanism of 110
- Puraka phase 111

- R—** Rechaka phase 116
- Rectus abdominis 24
- Red fibres 22

Reflex action 42
Relaxative asanas 83,89
Reproductive tissue 7
Respiratory system 14
Reticular formation 47
Role of Jalandhara bandha 115
Rotation 57,85

- S— Salient features of
—Cultural asanas 84
—Meditative asanas 94
—Relaxative asanas 89
Sensation 48
Sensory inputs 144
Sensory nerve 43
Sharir mala 125
Significance of double proportion
of rechaka 117
Sinus bradycardia 144
Skeletal system 53
Skeleton 53
Slightly movable joint 54
Small bones 54
Spinal cord 40
Standstillness of mind 133
- Static aspect of asana 70
Static posture 65
Stretch reflex 36
Suprarenal gland 51
Surya nadi 124
Susumna nadi 125
Swara yoga 133
Sympathetic nervous system 44
Systems 9,11,14,20,34,49,53,57

- T— Tadagi 141
Tadagi mudra 141
Tendon organ 31
Time ratios in pranayama 109

5495

Tissues 6, 7, 8

Thoracic vertebrae 56

Thyroid gland 51

Thyroxin 51

Topsy turvy asanas 85

Tri-iodo-thyronine 51

U— Uddiyana bandha 141

Uddiyana mudra 141

Ujjayi pranayama 129

V— Valsalva manoeuvre 145

Vama nauli 148

Vertebrae 54

W— White fibres 22

White matter 36

Y— Yoga—introduction 1

Yoga danda 125

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